AN INTRODUCTION
TO
GENERAL PATHOLOGY

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AN INTRODUCTION

TO

GENERAL PATHOLOGY

FOUNDED ON THREE LECTURES
DELIVERED AT THE ROYAL COLLEGE OF SURGEONS
LONDON, 1886

LEEDS & WEST-RIDING
MEDICO-CHIRURGICAL SOCIETY

BY

JOHN BLAND SUTTON, F.R.C.S.

SIR ERASMUS WILSON LECTURER ON PATHOLOGY, ROYAL COLLEGE OF SURGEONS
ASSISTANT-SURGEON, LECTURER ON COMPARATIVE ANATOMY, SENIOR DEMONSTRATOR OF ANATOMY
AND ASSISTANT-CURATOR OF THE MUSEUM, MIDDLESEX HOSPITAL

LONDON
J. & A. CHURCHILL
11, NEW BURLINGTON STREET

1886

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PREFACE.

The object of these "Lectures" is to endeavour to deal with the enormous collection of facts gathered together under the term Pathology, by the application of the fundamental principles of the doctrine of Evolution.

Born and educated in the country, my early boyhood was spent in the pleasant pursuit of studying animal life in fields, lanes, ditches, ponds, and hedges in the immediate neighbourhood of my home. Very many observations thus made have been to me of great service in my later studies.

On entering the medical profession in 1878 I soon became impressed with the view that much information concerning disease in the human subject could be gained by studying pathology in the lower animals, for my early observations led me to believe in the community of disease in man and in the lower animals.

In 1881 the Council of the Pathological Society, London, in accordance with a proposal made by Mr. Jonathan Hutchinson, instituted a Committee for the purpose of obtaining, exhibiting, and reporting on specimens of disease and injuries in the lower animals. It was my good fortune, through the kindness and exertions of my friend and former teacher, Mr. Henry Morris, to be appointed as one of the coadjutors to this Committee for the express purpose of conducting post-mortem examinations on the bodies of animals dying in the Gardens of the Zoological Society, which, through the kindness and influence of Professor Flower, had been placed at the disposal of the Committee by the Council of the Zoological Society. Such an unrivalled field for studying Comparative Pathology has probably never before presented itself to any worker. Every facility for investigating the diseases of the animals in this splendid collection has been afforded me by the Secretary, Mr. P. L. Sclater, the late Prosector, Mr. W. A. Forbes, and his successor, Mr. F. E. Beddard.

In addition to animals obtained from this source, I have availed myself of material wherever it could be derived, and Principal Robertson, of the Royal Veterinary College, has kindly furnished me with many interesting specimens and much valuable information.

In 1885 the Council of the Royal College of Surgeons elected me to the post of Sir Erasmus Wilson Lecturer, and the occasion seemed a suitable one to bring my observations publicly before the profession. The three lectures delivered in that capacity in February of the present year form the basis of the present volume.

The generalizations contained in these "Lectures" are the outcome of a very considerable experience. Since 1878 I have systematically examined the bodies of 12,000 animals, from fish up to man. In addition I have had access during the past eight years to the post-mortem room of the Middlesex Hospital, as well as every facility for studying the excellent pathological collection contained in its museum.

During the same period I have gathered much useful information from the subjects dissected in the medical school attached to that institution, and by encouraging my pupils to study the anatomy of the embryo, I have been enabled to carry out the dissection, with an especial eye to pathology, of more than 800 stillborn and immature fœtuses. Thus the statements made in these "Lectures" have been duly weighed, carefully considered and tested; and although many of them may hereafter turn out to be erroneous, I think they are warranted in the light of our present knowledge.

The examination of so large an amount of material has been very laborious. The work has been much lightened and facilitated by the ready and kind assistance I have always received from my friends and pupils at the Middlesex Hospital. Messrs. W. E. Wynter, E. B. Osmond, D. Thurston, W. G. Nash, W. G. Pridmore, and W. Marris have aided me in the matter of drawings. My brother, Mr. Septimus Sutton, assisted me in transferring the figures to the blocks. The Councils of the Zoological, Pathological, Clinical, Medical and Chirurgical, and Odontological Societies very kindly placed at my disposal electrotypes of the blocks which illustrate my papers in their "Transactions" and "Proceedings."

Professor Flower, Mr. Osbert Salvin, Mr. Jonathan Hutchinson, and Dr. Murie kindly granted me permission to use electrotypes of figures in their works. The source of wood blocks not cut especially for these "Lectures" is indicated in the adjoining list. My friend, Mr. Daniel Thurston, kindly shared with me the labour of correcting the sheets for the press.

J. BLAND SUTTON.

22, Gordon Street,
London, W.C.
May, 1886.

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AN
INTRODUCTION TO GENERAL PATHOLOGY.

INTRODUCTION.

It is a matter of daily observation that everything which lives, sooner or later dies. In the ordinary course of events, each animal organism has its limited term of existence, which for individual animals varies within the wide limits of a few hours to, it may be, one hundred and fifty years. It is the usual thing for animals that they shall be born, and if the environment be suitable they grow, attain maturity, reproduce their kind, and die. In all cases, however, such an unchequered course is not permitted. Dangers and disasters arise on all sides; the organism may fall a prey to some predatory animal, and its life end prematurely. Again, it may suffer injury whereby certain organs essential to the life and well-being of the creature are hindered in the satisfactory performance of their functions. Disease may affect the animal as a consequence of this perversion of function, whereby the organism is prematurely deprived of life. Besides this, there are many subtile causes of derangement of function, some of which arise within the organism, others enter it from without. The detection of these causes has engaged some of the brightest of intellects, and although much has been done in this direction, a great deal yet awaits accomplishment. It is the essential duty of Pathology to unravel these hidden causes of perverted function or disease.

Every competent Pathologist should make himself acquainted with the teachings of Comparative Embryology, which investigates the circumstances attending the development, birth, and growth up to maturity, of all animal forms. Anatomy engages herself with the details of the adult structure and mature tissues, whilst Physiology works out the function performed by the various organs and tissues in the normal (healthy) condition. When the structural details of the organism become disordered, and function is perverted, Pathology pursues the investigation.

Hence it clearly follows that it must be of decided advantage to any individual who ventures to investigate disease, that he should have the broadest possible conception of the phenomenon of life, esteem no living thing, however mean or lowly, to be unworthy his closest attention, for, as Paget beautifully puts it, "the highest laws of our science are expressed in the simplest terms in the lives of the lowest orders of creation."

The phenomenon of life may be studied in its simplest condition in the amœba, which may be described as a more or less minute nucleated mass of protoplasm; it has no limiting membrane, and is capable of moving with extreme slowness from place to place. If this small mass of protoplasm be watched under favourable conditions, we shall observe the nucleus to elongate, become contracted in the middle, and divide in two. The surrounding protoplasm also divides and accompanies each half of the nucleus. We have thus two individuals where before we had one. This is the simplest form of reproduction, and is known as "fission." Reproduction in amœba may arise by a small portion of the protoplasm becoming gradually separated from the rest of the mass; increasing in size it develops a new nucleus, and becomes exactly similar to its parent. This is known as "gemmation."

If we place one of these newly-formed amœba on a glass slide, and watch it by means of a microscope at intervals extending over a sufficient period, we shall find that its form is never constant, but that it is constantly protruding portions of its protoplasm in the form of bud-like projections or pseudopodia. If food-particles are supplied, the amœba takes them into its interior, where they are digested and assimilated—that is, the amœba is capable of transforming the food so that it forms part of its own protoplasm. As a result of this assimilation the amœba grows, and if the surrounding conditions be favourable it will attain the same size as the original form from which it sprang. This may be prevented from many causes. If, whilst we watch the minute mass of protoplasm, the temperature be raised to 35° C., the movements are arrested; but if this elevation be not sustained too long a time, the amœba will resume its movements—in fact, it recovers. The same phenomenon happens if we lower the temperature to the freezing-point.

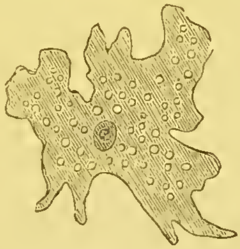

FIG. 1.—AN AMŒBA.

If the temperature be reduced below the freezing-point, or raised above 40° or 45° C., the movements entirely cease, and are not recovered on raising or lowering the temperature; the amœba is *dead*, or in other words, there is cessation of function. In the same way mild electric shocks are recovered from, but strong ones are not compatible with life. Thus a careful study of an amœba, one of the simplest of animals (its animal nature is determined by the circumstance that the amœba has to obtain its protein ready made, and is in the long run dependent for its existence upon some form or other of vegetable life), furnishes us with examples of life, nutrition and growth, reproduction, injury and two of the alternates to which it may lead—recovery, partial or complete, or death.

The amœba will furnish yet other conditions which will be useful for us to contemplate. If it is to maintain its normal state it must obtain, or be supplied with, material in the shape of suitable food-substance which is capable of being assimilated by the amœba and of undergoing transformation into protoplasm; thus the waste is equalized by the animal's power of assimilation. If from any cause nutrition be in excess of the requirements of the amœba, its protoplasm may exceed normal limits, and overgrowth result; or if nutrition be diminished, the protoplasm may degenerate and the amœba become reduced in size, thereby exemplifying two pathological conditions, degeneration and atrophy; the latter may exceed the limits consistent with life, and the amœba dies, its protoplasm afterwards undergoing disintegration.

If we examine the blood of a frog under the microscope, we shall distinguish readily certain curious colourless corpuscles known as leucocytes. If these colourless cells be placed under favourable conditions during the examination, they will be found to exhibit all the properties of the amœba—that is, they possess the power of moving, of throwing out pseudopodia, of ingesting particles, and of assimilation. If putrescent fluids containing bacteria be injected into the circulation of a living frog, and an interval of time be allowed, and blood then withdrawn, curious phenomena are seen; many of the white cells will be found to contain the bacteria, some will be found unchanged, others partially destroyed; but some of the leucocytes are dead—the bacteria have exerted a noxious influence upon them incompatible with life. We have here an example of the effects of a specific disease on an organism; if the cell can withstand the noxious agent it recovers; if the reverse, it dies.

The essential difference between the lowly amœba and the complex forms above the protozoa—the metazoa—is that they are compounds of amœba-forms in which individual cells perform separate duties—there is a *differentiation* of labour; and it must be borne in mind that all animals originate in an amœba form—the ovum. In metazoa certain cells persist in virtue of their contractility (muscle-cells), others for digestive functions; some secrete, others are for reproduction; some protect, whilst a few minister to the special senses, taste, sight, smell, and so on.

If, then, the majority of animals are to be regarded as masses of amœba-forms, it is essential that we should at the outset make ourselves thoroughly acquainted with all that pertains to these simple organisms—in fact, to be acquainted with the various kinds of animal cell and that peculiar substance of which they are composed—protoplasm—defined by some as the "physical basis of life."

It is necessary to advise the reader at the outset, to make himself thoroughly acquainted with the peculiar properties of this wonderful substance, whose capacities for growth are so marvellous that from a speck, not so large as a pin's head, a whale or an elephant may be developed. Unless he thoroughly grasps such remarkable facts as these, he will certainly treat many explanations of pathological phenomena offered in this treatise with scepticism.

If he should, on the other hand, hold so false a notion as to imagine that pathological processes occurring in man or in mammals can receive full elucidation from a study of such processes as they occur in the affected animal alone, let him read what the great John Hunter wrote on the subject, the man of all men most capable of estimating Comparative Pathology at its true value:—

"The human body is what I mean chiefly to treat of; but I shall often find it necessary to illustrate some of the propositions which I shall lay down from animals of an inferior order, in whom the principles may be more distinct and less blended with others, or where the parts are differently constructed, in order to show, from many varieties of structure and from many different considerations, what are the uses of the same parts in man; or, at least, to show that they are not for the uses which have been commonly assigned to them; and as man is the most complicated part of the whole animal creation, it will be proper, in the first place, to point out general principles, common to all the species of matter, that I may be better understood when I come to the complicated machine, namely, the human."—"Hunter's Works," vol. i., p. 220.

There are, however, two grand principles which even the orginal genius of Hunter failed to discern in their full bearing; these two grand principles are HEREDITY and VARIATION, the basis of the great doctrine of evolution so ably enunciated by Darwin, and which has acted like a magician's wand in enabling naturalists to marshal in orderly array, and in a philosophical manner, the stupendous mass of facts collected by Zoologists and Comparative Anatomists.

A satisfactory effort has not yet been made to introduce this doctrine into pathology; but it will be attempted in the ensuing chapters. The following three laws of evolution enunciated by Darwin's greatest disciple in this country, Professor Huxley,* will be abundantly illustrated. The laws are as follow:—

1. There has been an excess of development of some parts in relation to others.

2. Certain parts have undergone complete or partial suppression.

3. Certain parts which were originally distinct have coalesced.

Huxley uses the term "law" in the sense of a general statement of facts ascertained by observation.

A good example for the illustration of these laws presents itself in the female generative organs. Many forms—*e.g.*, the Cirripedia, land mollusca, etc.—are provided with male and female organs, constituting hermaphroditism. Ascending the scale of animated beings, we find, although every vertebrate possesses at some period of embryonic life male and female organs in a potential form, yet usually one set, either those peculiar to the female or those peculiar to the male sex, gain the ascendency. This serves as an illustration of the first law—that is, there has been an excess of development of one set of organs over the other. Associated with this excess we find suppression and more or less complete disappearance of the opposite set of organs. Thus we are furnished with an excellent illustration of the second law.

In the Ichthyopsida (fish and batrachia), and in the group

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* "Proc. Zool. Soc.," 1880.

Sauropsida (reptiles and birds), the female generative ducts are, for the most part, represented by oviducts (Müllerian) quite separate, although in birds one disappears. In most of the Mammalia the representatives of the oviducts fuse in the middle line through a greater or less extent, constituting a median uterus. This illustrates the third law, or coalescence of parts originally distinct.

My object in these "lectures" is to endeavour to show that the structural aberrations to which animal organizations are liable, and of which Pathological Anatomy takes cognizance, follow the same laws, which, when expressed in the terminology peculiar to that science, may be reduced to two:—

(1) Correlation
  (*a*) Hypertrophy.
  (*b*) Atrophy.
(2) Coalescence.

Correlation leads to abrogation of function, and gives rise to rudiments; these rudimentary structures or remnants may serve as the germs of origin of many forms of cysts and neoplasms.

SECTION I.

L & WEST-RIDING
URGICAL SOCIETY

CHAPTER I.

NUTRITION INCREASED—DEVELOPMENT IN EXCESS—HYPERTROPHY.

To anyone who has devoted serious attention to the matter, it must be evident that the term hypertrophy has come to be used by pathologists, physicians, and surgeons in an exceedingly indefinite manner, to include almost any kind of enlargement of the organs, limbs, or bones of the body, without that careful attention necessary to discriminate between simple overgrowth, functional enlargement, or increased size the result of adventitious elements in the part affected.

True hypertrophy may be defined as "the enlargement of an organ, partial or complete, beyond its usual limits, as the result of increased function, or of some unusual condition of the corresponding or correlated organ."

Before proceeding to discuss the question, it will be well to illustrate the definition with an example. Every known vertebrate normally possesses two kidneys, a right and a left one. In the case of the fowl whose left kidney is represented in Fig. 2, the right one had from some cause or other entirely disappeared; nothing but the ureter remained to inform us of the previous existence of the associated kidney. Such a case as this is by no means rare. I have observed it in five instances in man, also in sheep, oxen, horses, and twice in birds. The important fact in these cases is this—in all instances of single kidney, in size and weight the persistent organ far exceeds the normal, and in the majority of instances, is double the usual size. The kidney, in consequence of the loss of its fellow, has had to perform twice the amount of work usually required of it, and has doubled its bulk as a result of this increased functional activity.

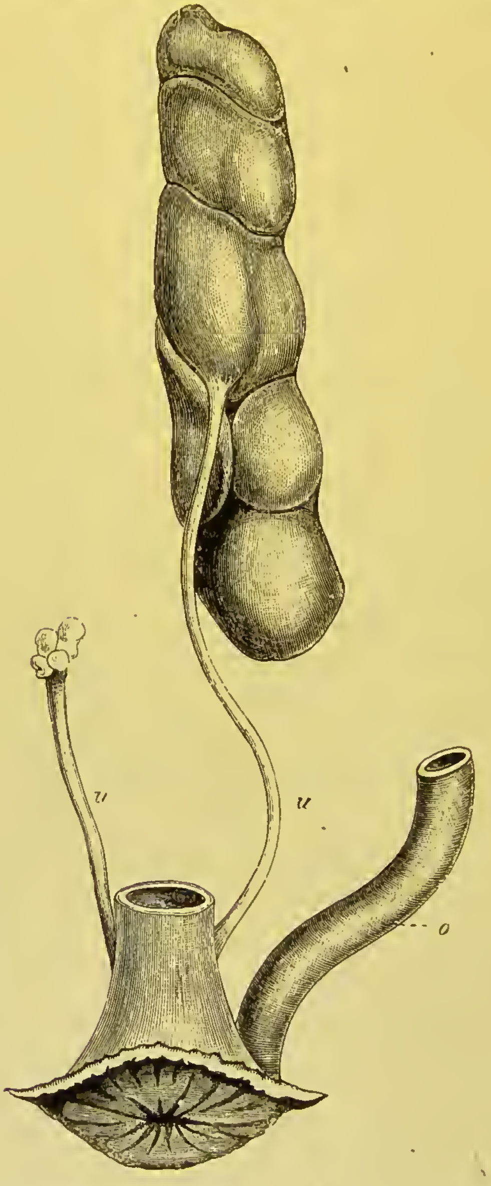

Fig. 2.—The Cloaca and Left Kidney of a Fowl.

The right one had disappeared, leaving merely the ureter, *u*, with a small collection of tissue at its summit to testify that a right kidney had existed; *o*, the oviduct. The persistent kidney is twice the natural size.

The next figure is interesting, for it exhibits an intermediate stage in this process, taken from a Hunterian preparation (Fig. 3). It represents the urinary organs of an Argus pheasant. The left ureter is dilated, and the corresponding kidney is very small, granular, and shrivelled. In compensation, the right kidney has increased to an unusual size, not by distension, but apparently by growth of its natural texture, so that by means of it as much urine may have been excreted as through both kidneys in the ordinary state. There is a corresponding difference in size in the renal arteries: the size of each is adapted to that of the organ to which it is distributed.

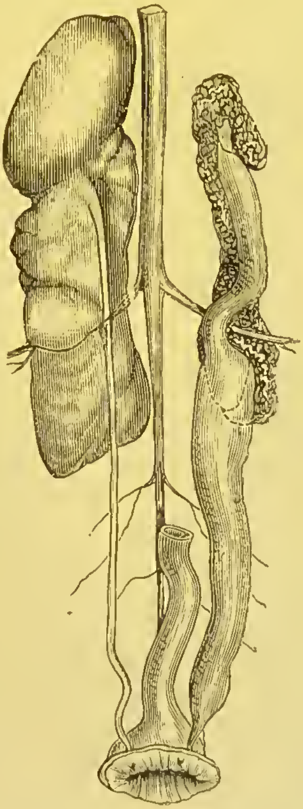

FIG. 3.—URINARY ORGANS OF AN ARGUS PHEASANT.
The left ureter is constricted at the spot where it joins the cloaca. This has led to dilatation of the ureter, sacculation and atrophy of the kidney.

The same collection contains a specimen illustrating a very rare example of hypertrophy. It is a testis taken from a monorchis. When divested of the tunica vaginalis, it weighed two ounces two drachms and two scruples. It was healthy in structure, and the epididymis was loaded with secretion. Although a careful examination was made, no testicle could be discovered on the other side.

In these examples we have to deal with genuine hypertrophy, and this must be separated from simple overgrowth. The most marked instances of overgrowth, as distinguished from hypertrophy, occur in connection with dermal organs, such as nails, hair, teeth, etc. In the case of the big toe represented in Fig. 4, the nail has grown enormously, so as to resemble a ram's horn in texture as well as in its twisted appearance; it was removed from an old woman, aged eighty-three, who had been bedridden many years. Such cases are by no means infrequent. If from any cause the wear of the nails be prevented, they are almost sure to attain considerable length. The same thing happens to animals when in confinement. Thus in the foot of the antelope (Fig. 5) the horny portion has grown unduly. The penguin's foot (Fig. 6) serves as an example of the same abnormal growth in birds. The beaks of birds belong to the same category as horns and nails, and like them suffer from overgrowth if not worn sufficiently.

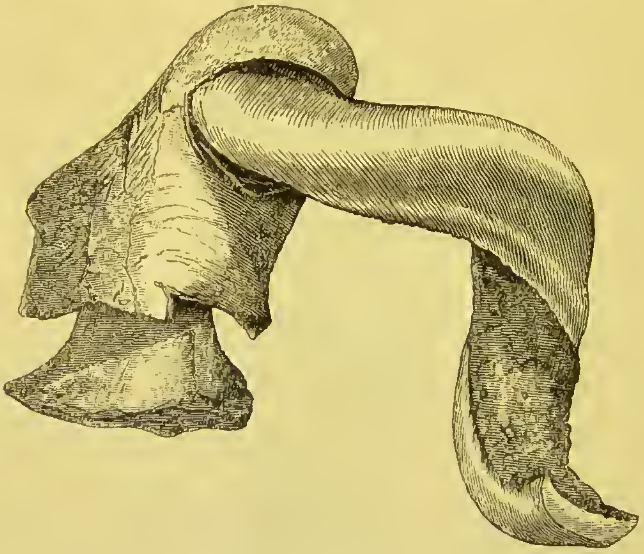

FIG. 4.—AN OVERGROWN TOE-NAIL FROM AN OLD WOMAN WHO HAD BEEN MANY YEARS BEDRIDDEN. (Nat. size.)

To show how difficult it is to draw the line where healthy function ends and disease begins, it may be mentioned that the long nails of the bats and sloths are actually useful, in that they suspend themselves by these appendages. I shall, in the last chapter, take occasion to show that they may have originated as abnormal structures.

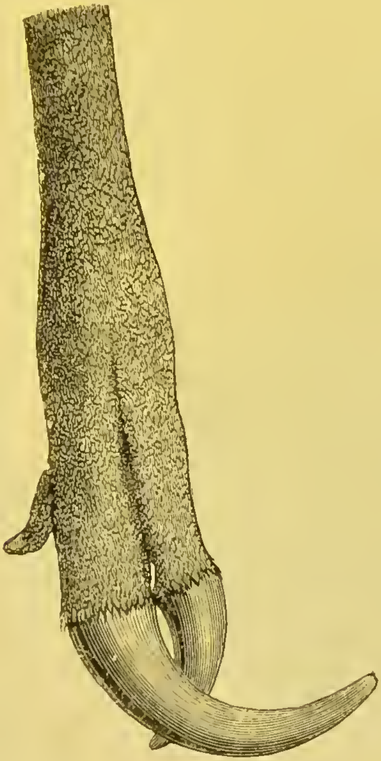

FIG. 5.—FOOT OF ANTELOPE WITH ABNORMALLY LONG HOOFS.

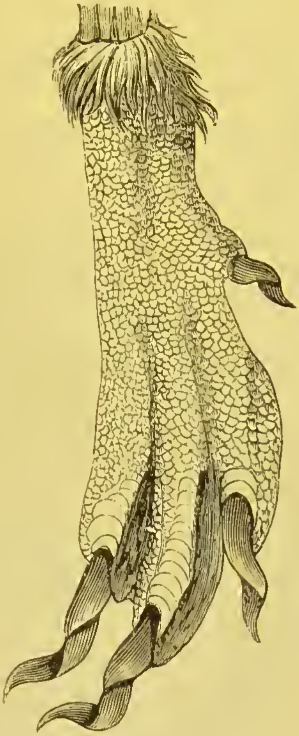

FIG. 6.—FOOT OF PENGUIN WITH ELONGATED CLAWS.

In such birds as parrots, when kept in confinement, it is often necessary to supply them with a piece of rough stone whereon they may rub the mandible in order to rid themselves of redundant portions.

The museum of the Royal College of Surgeons possesses some interesting examples of this variety of overgrowth in the partridge and fowl. It is also extremely common in old peacocks, parrots, and cage birds.

In Fig. 7 the beak of a parrot is represented, in whom the upper mandible has elongated to a very marked degree. The inferior moiety of the beak measures two inches, but the superior is six inches long, and is curiously curved, so as to come into close proximity with the bird's throat. It is remarkable that the bird should have lived to allow the beak to get so long, for it is difficult to see how feeding was accomplished.

It is interesting to note that in abnormal elongation of the mandibles the upper is always affected to a greater degree than the lower. The reason would seem to be this. When the parts grow abnormally long they tend, like the incisors of rodents, to describe a circle; by this means the edge of the lower beak works against the under surface of the upper beak, and is thus kept within normal bounds.

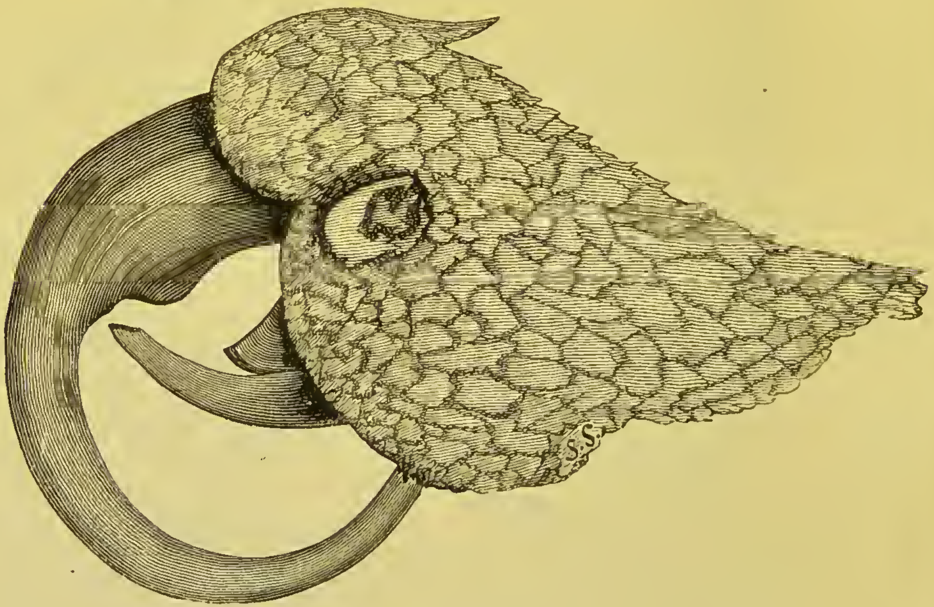

Fig. 7.—Overgrowth of the Beak in a Parrot.
(The drawing was made from the dried skin.)

The bird was found in Australia, and there was no evidence to show that it had lived in captivity. The constant curve associated with these enlarged beaks may be thus explained:—

When the stock-breeder wishes to make the horns of cows curl, in order to add to their beauty, he scrapes the inner side, thereby weakening them in that direction; as the horns grow they turn towards the scraped side. In the case of the parrot, a glance at the figure shows at once that the upper portion of the beak is being constantly scraped on its lower surface by the extremity of the mandible, hence the elongated beak curls in that direction. This explanation is of some interest in connection with the next form of overgrowth to be considered, viz., the teeth of rodents.

It is well known that the growth of the incisor teeth of rodents is unconditional: if their edges be not kept in check by constant usage, they would give rise to all sorts of serious consequences.

The most common causes of excessive length of incisor teeth growing from persistent pulps are—(1) slight mobility of the tooth in its socket, allowing it to be displaced by accidental pressure; (2) diminished usage, as when rats, beavers, marmots, and the like, are in captivity; (3) loss of antagonism of the teeth, either from fracture of a tooth, or of injury to the maxillæ, leading to displacement of the parts.

The following may be cited as examples of the first form, *i.e.*, displacement resulting from mobility of the tooth in its socket. Professor Owen, in his "Odontography," speaks of anomalies in the direction of elephants' tusks (Indian). "As when one tusk is horizontal, the other vertical. The tusk of this animal is slightly moveable in its socket, and readily receives a new direction of growth from habitual pressure; this often causes distorted tusks in captive elephants, and Cuvier relates the mode in which advantage was taken of the same impressibility, in order to rectify the growth of such tusks in an elephant kept at the Garden of Plants."

This mobility of the tusks in their sockets may explain the abnormal direction of the canines in the babirussa when kept in captivity. Several instances have occurred in which the curiously curved canines, from whence it takes its native name of "*deer hog*," have converged to the median line of the head, and, penetrating the hard skull, killed the animal.

It must be obvious that if this abnormal growth, or rather direction, of the teeth were common in the wild state all the best males would be exterminated; for it is certain that the more vigorous the male the more developed his tusks, and, to a certain extent, the greater his monopoly of the females.

Is it not possible that when confined in a limited enclosure the creature rubs the tusks against the sides of his prison, thus impressing an abnormal direction on the growing tooth? That these animals do like to rub their heads in this way is attested by the following instance. A babirussa, captive in the gardens of the Zoological Society, became so tamed that the keeper made a pet of it, and would play with the animal in its dwelling. One of the favourite habits of the creature was to rub its tusks against the keeper's legs, until they became as polished as an ivory ornament fresh from the turner's lathe. These teeth also took a false direction, and would have penetrated the beast's skull had they been permitted. Mr. A. D. Bartlett found it necessary to remove, from time to time, portions from the extremities of the aberrant tusks. They were cut three times, the pieces removed measuring, on an average, an inch and a half each.

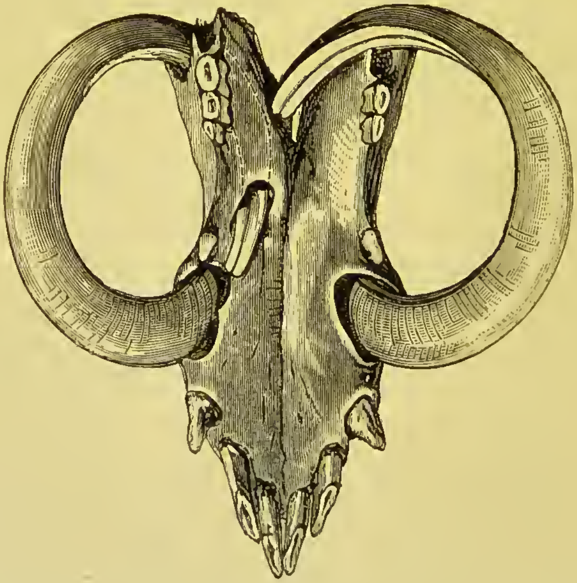

FIG. 8.—LOWER JAW OF BOAR WITH ABNORMAL CANINES.

One of the most remarkable examples of abnormality of direction taken by teeth, known to me, is the specimen figured by Cheselden in his "Osteographia," 1733, the original of which is in the museum of the College of Surgeons. The specimen consists of the fore part of the lower jaw of a boar. It contains the incisors, canines, and premolars. The lower canines have from some reason or other grown excessively, turned backwards, and re-entered the mouth by piercing the integument and the substance of the jaw. The right tusk has tunnelled the bone for a distance of three inches, and reappeared on the floor of the mouth near the symphysis. The left tusk, after re-entering the mouth, seems to have passed across the buccal cavity, so that its apex is resting on the inner side of the right lower jaw (Fig. 8).

The second cause of overgrowth, viz., that due to deficient usage, occurs frequently in rats, beavers, and other rodents. In beavers living in the gardens of the Zoological Society, it has been found necessary, from time to time, to cut the ends of their teeth to prevent the animals dying from starvation, notwithstanding the logs of wood and stumps of trees placed in the enclosure, whereon they can display their wood-cutting propensities. It would seem that the teeth of these rodents when confined grow at a greater rate than when the animals are in the wild state, this depending not only on diminished usage, but also on luxurious living. It is well established that tamed animals grow fat, and in many cases those born in captivity exceed in size those brought forth in the wild state. It is so with rabbits, and also with regard to lions and tigers. It stands to reason that an animal with its food ready to hand will grow fatter than one who has to hunt and exert its physical powers to obtain the necessary quantity of aliment; it may not be so healthy, but it grows and increases in size in greater proportion than its wild brother. That the teeth should share in the general increased rate of growth is not to be wondered at. In an agricultural paper it was noticed that a question had been raised concerning the age of some prize pigs; the point urged was that the animals' teeth did not correspond with their reputed age, and evidence was adduced to show that teeth appear earlier in pigs which are undergoing the fattening process.

The third variety, or that due to injury of the teeth or maxillæ, does not differ from the preceding varieties in the ultimate effects of the accident. I shall therefore be content with simply quoting one illustrative case. It concerns the right inferior maxilla of a rabbit, which had, from some cause or the other, sustained fracture at the junction of the body with the ramus. No union has taken place, and, judging from the rounded appearance of the opposed surfaces of the fragment, it would seem that the injury must have been of some standing, and that a false joint had formed. In consequence of this lateral deviation of the maxilla, apposition of the incisor teeth had been interfered with, and the lower set had grown excessively. The upper incisors are longer than usual, and their sharp edges came into contact with the gum of the right lower maxilla, leading to inflammation and deposition of new bone from the periosteum. Some of the molars have also exceeded their length, where they failed to meet the upper set in consequence of the lateral deviation (Fig. 9).

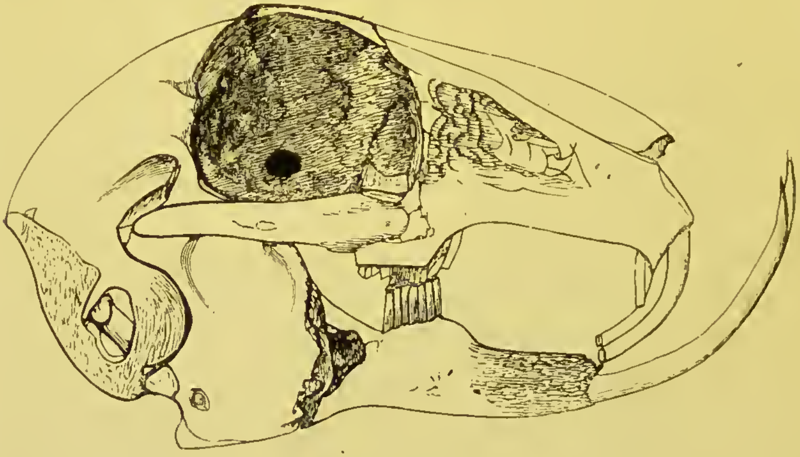

FIG. 9.—SKULL OF A RABBIT WITH UNUNITED FRACTURE OF THE LOWER JAW, WHICH HAS LED TO NON-APPOSITION OF THE INCISORS, AND OVERGROWTH IN CONSEQUENCE.

A striking feature in connection with these abnormal teeth is their tendency to describe a circle. In some cases this is so complete that the point of the growing tooth has actually entered its own pulp-chamber. This disastrous result is illustrated by the tooth of a hippopotamus preserved in the museum of the Odontological Society of Great Britain. Professor Owen endeavoured to account for this peculiarity by imagining that the curve protected the pulp from the effects of direct pressure, but the explanation advanced to account for the curving of the parrot's beak and similar cases is applicable here, for the posterior aspect of the teeth is the part which wears first, the anterior hard coating of enamel being the last to yield; so that the act of gnawing corresponds to the scraping of the beak and the cow's horn mentioned on page 16. The question of abnormal growth of teeth has been discussed at some length, for arguments will be raised on these cases when later we come to consider some extraordinary forms of dentition which characterize certain species of mammals, especially the *Suidæ* and *Cetacea.*

Bones are very liable to become enlarged, but it is necessary to exhibit caution in determining whether any particular specimen is an example of hypertrophy or overgrowth. It is exceedingly common to find in animals, and among men, examples of skulls exceeding their normal thickness many times when affected with rickets and similar diseases. These enlargements must be rigorously excluded from hypertrophy; they are no more worthy of the designation than the enlargement of the sural muscles in that remarkable disease, pseudo-hypertrophic paralysis. Indeed the same cause has been at work in the two cases—gradual increase in the connective-tissue elements of the part. In the case of bone, the new tissue undergoes ossification, but in the case of muscle it is too much to expect fibrous to become muscular tissue. In all these cases the skull bones, which arise primarily in membrane, are those mainly affected. In such instances as these the increased thickness arises from disease of the formative tissues, and is not the result of atrophy of some other part; neither has it increased function to perform; hence it seems to me that the term hypertrophy is used in too elastic a sense when applied to such conditions.

The following is a typical case of hypertrophy:—An old man, whose body bore manifold traces of the ravages of syphilis, was brought into the dissecting-room. It was found that he had an ununited fracture of the tibia. Inquiry showed that this false joint had existed for ten years, and the man used to bandage the leg tightly, and then fix the fragments by means of wooden wedges forced in between the bandage and the leg. The result of this proceeding has been to modify the bones of the leg in an extremely remarkable manner. It will be seen, on reference to Fig. 10, that the tibia in the immediate neighbourhood of the false joint has dwindled to

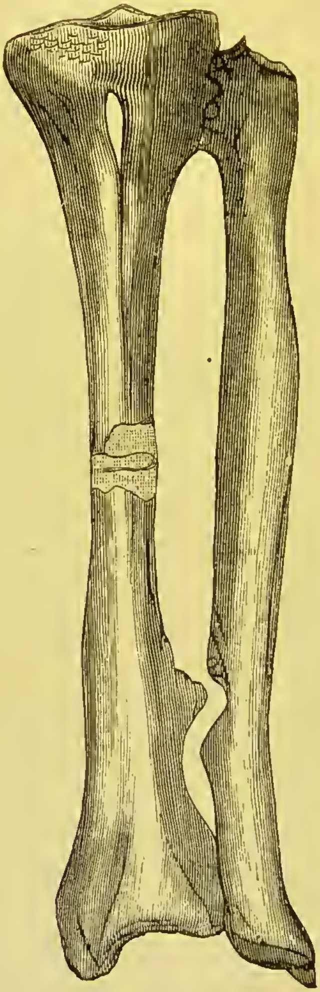

Fig. 10.—A Tibia and Fibula.

The tibia is the seat of an ununited fracture; the fibula has undergone compensatory hypertrophy.

the size usually presented by an adult fibula; the opposed ends of the fragments are smooth and rounded, gliding one upon the other like the surfaces of an ordinary joint, and the ends are enveloped by a capsular ligament. The fibula has increased in size enormously, exceeding its normal transverse section three times. It has had to perform an increased share in supporting the body, and has hypertrophied to meet the demand. Increased function accompanied by increased blood-supply have been the main factors in producing this very desirable result. The diminished size of the tibia results from two causes, viz., the continued pressure of the bandage and the wooden plugs, as well as diversion of the blood-stream to meet the demands of the enlarging fibula.

We must now proceed to consider examples of the purest kind of hypertrophy. Take the heart, which, like all muscular organs, develops its contractile tissue according to the amount of work required of it. Before birth both ventricles share the labour of distributing the blood equally—each has walls of similar thickness; after birth the right ventricle ministers to the wants of the pulmonary circulation only, the left one bears the burden of the systemic circulation, a duty involving considerable expenditure of muscular energy. As a consequence, its walls thicken and exceed the right in the proportion of two or three to one.

In cases of malformation it occasionally happens that the ductus arteriosus and foramen ovale fail to close; the condition of the heart remains much the same as in fœtal life, the right ventricular walls equalling in thickness those of the left.

If the valves of the heart become incompetent from any cause so as to permit regurgitation of blood from the aorta into the left ventricle, increased labour is thrown upon the walls of this cavity to eject an increased quantity of blood at each systole; in consequence, hypertrophy of the contractile substance occurs to meet the demand. Illustrative specimens of this form of compensatory hypertrophy in man's heart may be found in all pathological museums of any pretension. Precisely similar changes occur in the ventricles of animals, especially horses. The bladder is often the seat of this kind of hypertrophy, when obstruction hinders the free flow of urine, as in stricture, stone, etc., in young men.

Exactly similar changes take place when a gall-stone obstructs the common bile-duct, or a calculus plugs a ureter; but these are familiar examples, and even cease to stimulate interest, they are so common.

The gizzards of birds afford interesting examples of this very valuable process. It is well known that the birds which now adorn the earth are devoid of teeth; in order to meet this apparent defect, the walls of a definite portion of the alimentary canal in many species have increased in thickness, and given rise to a peculiar muscular organ with thick walls, known as the gizzard. The interior of the gizzard is lined with thick callous material, and into this chamber the food, with small stones, is lodged for a time, and submitted to the triturating action due to the contraction of the gizzard walls, whereby it is reduced to a fine state of sub-division. Two chief types of gizzards may be distinguished. In the simpler form the walls are less thick than in the other type, and it is found in such birds as are carnivorous or insectivorous in their habits, and in those which live on soft fruits. The structure of the gizzard may be thus described: the muscles radiate from two tendinous centres, which are placed one on either side of the organ, the muscular fibres passing from one to the other. The second form exhibits increased development of its lateral muscles, and its lining membrane becomes converted into a hard, horny layer. Every intermediate condition of muscularity of this organ may be found in birds, from the simple gizzard found in the Raptores, up to the most muscular one of Anserine birds. Hunter long ago proved that the muscularity of the gizzard depends upon the nature of the food which the bird obtains. He fed a seagull for a year on barley, and found that the muscular tissue of the gizzard became enormously developed.

It is stated that the herring-gull, *Larus tridactylus*, of the Shetland Islands changes its food twice every year, in the summer living on grain, and in the winter on fish, and the structure of the gizzard changes according to the nature of the food. Holmgrén has made the experiment of converting the stomach of the grain-eating pigeon to the carnivorous type, and similar observations have been made on the raven and the owl (Bell).

Perhaps the most interesting of all gizzards, as proving the plasticity of the organ, is that of the fruit-pigeon, *Carpophaga latrans*, of Fiji. This bird lives on the fruit of *Oncocarpus vitiensis*, a tree belonging to the natural order *Anacardiaceæ*. The fruit of this tree is very curious and corky, somewhat resembling the fruit of a walnut. No stones were found in the gizzard of the bird, but in order to enable it to crush this hard fruit, the inner lining of the gizzard is raised into hard horny cones, not ossified in any part, but corneous throughout, and of the density of ox-horn. Garrod's admirable and detailed account of this curious structure will be found in "Proc. Zoo. Soc.," 1878, p. 102. The accompanying drawing (Fig. 11) affords a very good idea of these cones.

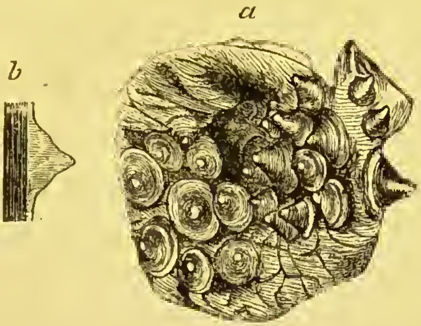

FIG. 11.—THE GIZZARD OF CARPOPHAGA LATRANS TO SHOW THE CONES. (After Garrod.)
b shows a cone in side view.

A further, but exaggerated, example of this condition has been described in the gizzard of *Phænorhina goliath* of New Caledonia.*

I have been induced to describe the case of this bird here, for it is an admirable illustration of Hunter's account of the cause of corns, viz., hypertrophy, the result of pressure from without, or, as it is more correctly rendered now, intermittent pressure.

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* MM. Jules Verreaux et O. Des Murs, "Revue et Magasin de Zoologie," 1862, p. 168.

The anatomy of a corn is represented in Fig. 12. A little toe is shown in longitudinal section; the epidermis over the first phalangeal articulation has become thickened in consequence of the intermittent pressure from ill-fitting shoes or boots. Beneath this thickened epidermis a bursa often develops, and frequently some twigs of the short saphena nerve spread over the bursa-wall, at times causing great pain, radiating even as far as the popliteal space.

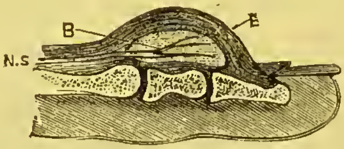

FIG. 12.—THE ANATOMY OF A CORN.

E, thickened epidermis; B, bursa; N S, a twig of the short saphena nerve spreading over the bursal sac.

In some monkeys, the group *Cynomorpha*, which includes the baboons and macaque monkeys, there exist characteristic pads of naked hard skin over the tuber ischii, exactly on the spots upon which the body rests when the monkey is in a sitting posture. These callous pads are termed ischial callosities. They are of great size and thickness in the baboons, but very small in the Gibbons, which are the only anthropomorphous apes in which they are known to exist.

It is universally admitted that intermittent pressure, due to ill-fitting boots, or on the hands as a result of occupation, leads to an increase in the thickness of the skin pressed upon; so in the case of those monkeys possessing ischial callosities, we have to deal in reality with a corn the result of intermittent pressure, but with this difference—the corn has been inherited. Corns are pathological productions beyond all dispute. Ischial callosities are in structure corns, except that loose fibro-cellular tissue is interposed between them and the bone, instead of a definite bursa; but a bursa is not a constant characteristic of corns in man. Seeing that ischial callosities agree in structure, function, and in causation with corns, it is not visionary to regard them in those monkeys in whom they occur with such constancy, as inherited pathological conditions.

This view of the case is materially strengthened by the circumstance, which no one would venture to dispute, that bursæ are inherited; every human being and all domesticated animals bear proofs of this in their limbs. If bursæ may be inherited, so may ischial callosities.

Although a corn is to the human being who possesses one, a source of considerable discomfort, nevertheless these structures are in certain instances of great value to some animals, especially the carnivora; for the callous pads on the soles of their feet are to all intents and purposes corns in function as well as in structure. Further, during the last few years the attention of surgeons has been directed to the occurrence of a peculiar form of ulceration which attacks corns, known as the perforating ulcer, which is associated with nerve-lesions, peripheral as well as central. It is interesting to note that the callous pads, or corns, on the feet of a Civet cat were found perforated by ulceration; the animal had degeneration of the spinal cord and peripheral nerves, so that in disease these pads behave as corns. (For full details of the case *see* "Path. Soc. Trans.," vol. xxxvii.) The hard callous pads on the breasts of camels are in all probability of the same character.

Having illustrated the points which should guide us in distinguishing between simple overgrowth and true hypertrophy, it is well that we should inquire into the causes of the process. They range themselves under two headings—(*a*) increased function; (*b*) increased blood-supply.

A very little reflection will soon convince one that these two causes are for the most part inseparably united; but there are some few instances where the hypertrophy appears to be dependent on increased blood-supply alone, but they are exceptional. The following is a case in point. In the human fœtus at birth the legs are relatively much shorter than in the adult; but after birth the legs grow at a greater rate, and in the adult exceed their infantile ratio to the body no less than one and a half times. All this change results in a great measure from the closure of the hypogastric arteries, whereby a larger proportion of blood is directed to the lower limbs, accompanied by a corresponding increase in size of the external iliac arteries. The gradual and perceptible enlargement which takes place in the temporal artery after ligature of the common carotid, is an example of the remarkable plasticity of arterial trunks. In favourable cases the artery may be felt dilated within a few hours of the operation. The rapidity with which arteries dilate or contract to meet the requirements of their dependencies, is a fundamental feature in all cases of hypertrophy.

The various instances detailed in this chapter are sufficiently convincing, in that they indicate clearly enough that hypertrophy must be distinguished from simple overgrowth. The latter condition occurs with extreme frequency and from a variety of causes, whilst hypertrophy is anything but common in its occurrence. It will be necessary again to return to this subject when dealing with the correlation which exists between atrophy and hypertrophy; but it is hoped that this section has already served to demonstrate the care which is essential in distinguishing true hypertrophy from its counterfeits.

CHAPTER II.

NUTRITION IMPAIRED—ATROPHY.

Atrophy manifests itself by diminution in the size of the affected organ — microscopically by diminution and often ultimate disappearance of the constituent elements special to it; hence it may be defined as a retrogressive change in parts originally well-formed and well-grown. It is in this sense that the term atrophy is usually employed by pathologists. As a physiological process, atrophy is always taking place, for the several tissues, like the organism itself, live, multiply, and die, the duration of life of any of the tissues being always much less than that of the individual whose structure they compose.

Thus atrophy only comes to be considered as pathological when it oversteps normal physiological bounds.

The mammalian fœtus abounds in structures which pass through a measured lease of life, their function being either unnecessary to the well-being of the organism, or abrogated by some more efficient organ. The shrivelling of the vitelline duct, hypogastric arteries, ductus arteriosus, umbilical vein, ductus venosus, Wolffian bodies, the various ducts connected with the generative organs, and a very considerable portion of the chondro-cranium, may be mentioned as a few clear and indisputable examples. Later on in life, when senility becomes evident, physiological atrophy manifests itself in the sexual organs in the female—the uterus, ovaries, and mammæ; but if these parts suffer diminution early in life, then the atrophy comes to be pathological, hence hard and fast lines of distinction can nowhere be drawn.

Extending our view over the whole animal kingdom, very remarkable instances of physiological atrophy crowd upon the observer. Among curious examples of suppression of parts, or atrophy, must be mentioned Professor Parker's* very interesting observation on the development of the green turtle. Parker found that in the embryo of his third stage, about six and a half lines long, fifty-one somatomes exist, but in the adult, forty-one vertebræ only are found. The number of somatomes in the dorsal, lumbar, and sacral regions is equal to the number of vertebræ in the adult, but in the cervical region seven somatomes abort, and in the caudal region three.

This singular suppression of parts in the embryo suggest an ancestry with longer necks and tails than are found in the forms which now exist.

It may be broadly stated that the converse of those processes which lead to hypertrophy are the potent causes of atrophy; and as atrophy of one organ gives rise to hypertrophy of its fellow, so will hypertrophy of one organ bring about a marked atrophy of some closely-correlated organ.

In the fœtus, the advent of the kidney, or metanephros, and its assumption of the function of secretion, bring about the atrophy of the Wolffian bodies, or mesonephros. When the tadpole commences to metamorphose into a frog, the gills, as respiratory organs, become superseded by the lungs, and atrophy in consequence. Before birth the ductus arteriosus is double the size of the pulmonary artery; but when pulmonary circulation is established, the reverse condition pertains, the ductus eventually shrivelling.

There is no tissue or organ of the body capable of resisting atrophy. Even the bones of limbs which have long been paralysed, and consequently disused, become reduced to the thinness of quills, and in some cases are as fragile and delicate as egg-shells. Examples may be seen in any pathological museum.

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* "Zoology of the Voyage of H.M.S. *Challenger*," "The Development of the Green Turtle," p. 48.

In the preceding chapter we saw how rapidly the heart accommodated itself to the demands for increased action; so, too, if less work be required, its size will diminish. In young subjects, after amputation at the hip-joint, the size of the heart undergoes diminution, and the external iliac artery of the affected side dwindles not only in lumen, but in the thickness of its coats, until it is only half as large as the corresponding artery of the opposite side. These changes may be demonstrated within ten weeks from the time of operation.

When considering hypertrophy, it was shown that increased functional activity demanded increased blood-supply to the part, and this led to enlargement of the organ or tissues in consequence. Diminished functional activity means a less supply of blood, and leads to diminution in the size of the organ, which, if it reaches an unusual limit, becomes pathological.

The eyes of some of the inhabitants of the Mammoth Cave of Kentucky supply good examples of atrophy. In this cave the eyes are of no service, for light never penetrates its dark recesses; hence they suffer atrophy. That these blind animals are descendants of forms which had functional eyes is shown by the circumstance, that in the crustaceans inhabiting the Kentucky caves the eyestalks are present in their normal situations. Perhaps the most interesting specimen from this cave is the blind fish *Amblyopsis spelæus*. For an admirable account of the eye-specks and their atrophied nerves the reader should consult an article by Jeffries Wyman, in "Silliman's Journal," 2nd series, vol. xvii., p. 258, in which this anatomist endeavours to show that the semicircular canals are unusually large in this fish. It is said that blind fish are acutely sensitive to sounds, as well as to undulations produced by various causes in the water. It is curious to note that in this instance, as in some others to be mentioned later, that the pigment is always a very conspicuous element in these disused and atrophied eyes (Fig 13).

The proteus from the caves of Carniola, in South Austria, and the fish, *Lucifuga dentata*, from the subterranean caves of Cuba, are similarly affected.

In several forms of deep sea fishes, especially those which have descended to such great depths that few, if any, rays of light reach them, the eyes are rudimentary, and in some cases covered with skin.

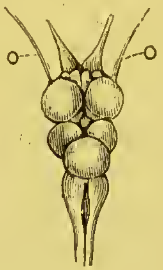

Fig. 13.—Brain of *A. Spelæus*, showing the Atrophied Optic Nerves.

Mr. F. E. Beddard,* in his report on the *Challenger* "Isopoda," points out that in some of the species included in the genus *Serolis* it is possible to trace the various stages by which the eyes of these animals have retrograded from the conditions seen in the shallow water species, to their almost complete disappearance in the deep sea form, *Serolis antarctica*.

In the well-known case of the mole, whose underground life prevents it making good use of its eyes, they in consequence have degenerated in size, so as to be mere specks in the integuments. Yet with all this, if in the fœtal mole sections of the eyes be carefully made, all parts may be distinguished—sclerotic, choroid, cornea, lens, and retina. It is necessary to mention that there are some good reasons for believing that the rudimentary state of the eyes, and their position beneath the integuments, in burrowing animals may be in part due to other causes than simple atrophy from disuse.† Probably, as a consequence of this loss of their external representatives, the anterior quadrigeminal bodies have suffered atrophy.

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* "Report on the Isopoda—The genus *Serolis*," "The Zoology of the Voyage of H.M.S. *Challenger*."

† See chapter xxii.

This coincident atrophy of the anterior quadrigeminal bodies is not altogether speculative. On one occasion it was necessary to remove the eye of a young dog for glaucoma; the animal died three months after the operation, the optic nerve was reduced to a mere thread, and a decided difference in size could be detected in the anterior quadrigeminal bodies.

Similar cases have been observed in man. Experiment goes to show that if the eyes be extirpated in the young animal, the operation is followed, some time after, by a diminution in size of the anterior quadrigeminal bodies (Gudden). Nevertheless the evidence is not conclusive, for in the case of the blind fish, *Amblyopsis spelæus*, the optic lobes are as much developed as in fish possessing perfectly developed eyes.

Similar changes occur in muscles, if from any cause they are hindered in the due performance of their function; their highly-elaborated protoplasm suffers degeneration, and atrophy is the consequence. It is not any more remarkable that when the dominant nerve of a muscle is cut its essential tissue should atrophy, than that the retina should become insensible to light when the optic nerve is cut. The muscle, or rather its contractile tissue, is the peripheral end-organ of the nerve as much as the retina is of the optic nerve—destroy one, and the reason for the existence of the other is at an end, degenerative changes ensue, and atrophy is the consequence. It matters not whether the peripheral end-organ (retina, muscle, etc.), or the line of communication (the nerve), or the terminal end-organ (the nervous centre) be destroyed, the result is the same in all cases.

The museum of the Royal College of Surgeons, London, possesses an interesting illustration of atrophy from disuse. It is a part of the pelvic viscera of an adult Russian, from whom the penis, scrotum, and testes were removed in early adult life. The scrotum is represented by a flattened eminence of cicatricial tissue. The prostate gland is atrophied, the vasa deferentia are thread-like, and the vesiculæ seminales are without their natural pouchings.

Closely parallel to this case was that of a monkey who came under my notice some long time after castration had been performed. In this case the penis was very small, the vasa deferentia as thin as cotton, and found with difficulty; the vesiculæ seminales were dwarfed, shrunken, and embedded in fat. This animal had lived in a private house for a long time, but when put into the monkey-house in the Zoological Society's Gardens was quickly murdered by the irate monkeys who were to have been his companions.

A good example of atrophy from disuse is furnished by the large bowel when it has been rendered useless by the operation of left lumbar colotomy. In these cases the fæces are usually hindered from entering the lower segment of the gut on account of a projecting spur of mucous membrane which forms the well-known éperon. The gut, from the spur downwards, becomes reduced to the consistence of a fibrous cord if the patient survive the operation any length of time (Fig 14).

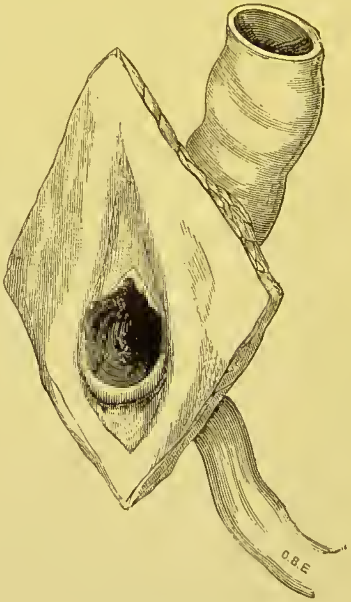

FIG. 14.—PARTS CONCERNED IN LEFT LUMBAR COLOTOMY, TO SHOW THE ATROPHY OF THE GUT BELOW THE ARTIFICIAL OPENING.

The skull occasionally undergoes a curious form of atrophy. Thus in the case of an old woman, aged eighty-three, who had been bedridden for many years, the following was the condition presented by the skull:—The bones are light and porous; there is general diminution in the weight, which is fourteen ounces, as compared with twenty-four, the average weight of a European skull. The cranium is probably diminished in size, for, notwithstanding its age, the sutures are unobliterated, save in the region of the obelion, and when examined by transmitted light are peculiarly obvious and transparent. The orbits are large and out of all proportion to the size of the skull. The alveolar margins have undergone absorption in consequence of the loss of the teeth, and at the posterior part present an eburnated condition. The foramina in the base of the cranium are large, and the fissures widely open; but the bones forming the vault have atrophied more than those of the base. The lower jaw has a circumference greater than that of the upper, and the symphysis in the dried skull projects more than an inch beyond the alveolar margin of the upper jaw. It is extremely atrophied, and weighs one ounce. In this instance similar changes had occurred in the pelvic bones, for the ossa innominata and sacrum weighed eight ounces, whereas those from a healthy woman, compared with them, weighed eighteen ounces.

There are two skulls in the museum of the Royal College of Surgeons, London, which this resembles. One is a Hunterian preparation, the other belonged to a Wallachian gipsy woman, aged eighty-two, and weighs only 10·7 ounces. In both these cases the bone is so exceedingly thin that it bends, and crackles as it bends.

Apart from local atrophy, there are other instances of the atrophy of an organ, which, though local, are attended with some very extraordinary general effects. Some of these will now be considered.

Effects of Atrophy of the Ovary.—John Hunter has placed on record some interesting facts bearing on this question, in his account "Of an Extraordinary Pheasant." It appears that now and then a hen pheasant is seen with the feathers of a cock; the animal does not breed, and its spurs do not grow. Dr. Pitcairn received a bird of this kind from Sir

Thomas Harris, and showed it to Sir Joseph Banks and Dr. Solander; Hunter being present, examined the bird, and found it possessed what he termed *two ovaries and oviducts.*

Among the other cases instanced by Hunter, the following is the most remarkable :—

Lady Tynte had a favourite pyed pea-hen which had produced chickens eight several times. Having moulted when about eleven years old, the lady and family were astonished by her displaying the feathers peculiar to the other sex, and appeared like a pyed *peacock.* In this process the tail, which became like that of a cock, first made its appearance after moulting; and in the following year, having moulted again, produced similar feathers. In the third year she did the same; and, in addition, had spurs resembling those of a cock. She never bred after this change in her plumage, and died in the following winter during the hard frost, in the year 1775-76.

These facts are extremely interesting, for, as Hunter points out, we find similar changes taking place in the human species; for the increase of hair observable on the face of many women in advanced life, is an approach towards the beard which is one of the most distinguishing secondary properties of man.

When females pass the child-bearing period of life, that is when the ovaries become functionless, they often assume more or less masculine characters.

Yarrell communicated a paper to the "Phil. Trans.," 1827, on the subject; the following is the pith of his researches :—

He had an opportunity of examining seven hen pheasants, in plumage more or less resembling the male, and in all of which the sexual organs were diseased, but with some variation as to extent. The ovary was contracted in size, of a purple colour, and hard to the touch. The oviduct was diseased throughout its whole length.

Some cases are also quoted at length to show that the change in the sexual organs precedes the alteration in the plumage. That this change in the feathers is secondary to affections of the sexual organs the following facts bear testimony :—

The poultry-breeder learns, from the attempts of the young bird to crow, that the testes have enlarged sufficiently for him to perform castration. After the operation is performed the bird never crows again. The combs, gills, and spurs remain short and blunted, and the feathers put on an appearance intermediate to those of the cock and hen.

The operation on the female bird consists in making a small incision through the skin on the flank of the left side, and so on until the oviduct is reached, and a piece cut away. After the operation the ova do not enlarge, and the hen makes an attempt to imitate the crow of a cock; there is an increase in the size of the comb, and a spur or spurs shoot out, but remain short and blunt. The feathers also undergo a change in colour.

Another peculiar feature in these unsexed hens is the singular shape of the lower part of the back, due to the want of enlargement of the bones observed in all true females, by which they attain a breadth of the pelvis sufficient to allow the eggs to pass.

It is well known that the beautiful plumage which many birds assume in the spring is coincident with the dilatation of their sexual organs under the influence of the genial weather.

Yarrell entered carefully into the matter of disease of the sexual organs being a cause of this singular change of plumage, because Dr. Butter, in the "Wernerian Transactions," vol. iii., states that all hen birds would acquire this change of dress if they lived to be old enough; this, of course, is erroneous—*when the change comes on in old birds it is the result of the cessation of ovarian activity.*

Professor Turner has described, in "Proc. Roy. Phys. Soc.," Edinburgh, vol. iii., p. 297, 1862-66, a bantam hen, aged thirteen, which had assumed male plumage and developed a well-formed spur on the left leg. The ovarium was shrivelled and the ova atrophied. Numerous pea-like bodies, containing a yelk-like fat, were either lying loose in the abdominal cavity or attached by short pedicles to the peritoneal lining. They seemed to be aborted or degenerated ova.

Darwin refers to the fact in the "Descent of Man," as though it were well recognized. After writing concerning the females of certain species of birds which, in the first year or two after they are hatched, differ in colour from the males, nevertheless later in life naturally acquire the coloration, etc., of the male (*Falco peregrinus*, *Bombycilla carolinensis*, *Palæornis javanicus*), he says—

These cases must not be confounded with those where diseased or old females abnormally develop masculine characters.

In cases of hermaphroditism occurring among Lepidoptera, one side presents the characteristics of the male, the other side those of the female. Also the female may assume the coloration of the male where normally the colour of the two sexes widely differs (J. Jenner Weir, "Entomologist," August, 1883).

Dr. Larcher has published, in the "Journal de l'Anatomie et de la Physiologie," November, 1873, an article on "Les Affections des Parties Génitales Femelles chez les Oiseaux," where, among other conditions, this relation between feathers and sexual organs is discussed, and further evidence offered, so that the phenomenon in question is beyond doubt.

The most remarkable instance of change of plumage in a hen bird that has come under my own notice concerns a female golden pheasant which lived in the pheasants' aviary in the Zoological Gardens, London. A pair of birds, male and female, were given to the Society by Sir H. W. Tyler, M.P., but the hen bird presented all the resplendent dress of the male bird, even to a slight yellow coloration on the legs. On comparing her with the male bird, the following differences only were perceived:—The eye was perfectly dark, whereas in the male bird a ring of white encircles the iris, and the colour of the plumage was not quite so brilliant as in the male, and she had no spurs. Mr. Misselbrook, the head-keeper at the Gardens, informs me that the bird had undergone two moults. In spite of the deceit of feathers, the male bird lived with her quite happily for two years, and they had not been seen to fight. On several occasions I have seen a male bird in the next cage, who was companionless, making overtures towards his neighbour's hen in spite of the assumed plumage.

The ultimate fate of the bird, however, was rather tragic, for in the spring of 1885 she would not yield to the solicitations of the male, and he killed her. The post-mortem examination showed the ovary dwindled to the dimensions of a pea (Fig. 15).

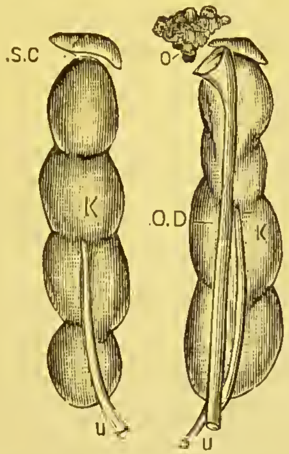

Fig. 15.—Atrophied Ovary of a Golden Pheasant.
K, kidneys ; S C, supra-renal capsule ; O, ovary ; O D, oviduct ; U, ureter.

Simpson* gives an account of this curious change of plumage in birds, and points out that Aristotle was acquainted with the circumstance ("Hist. Animal.," lib. ix., cap. 36).

The following is a list of the birds in whom it has been observed:—

The common fowl. Tucker, Butter, Jameson, Yarrell, Butler, Turner, Author.

The common pheasant. Hunter, St. Hilaire.

The golden pheasant. Blumenbach, St. Hilaire, Author.

The silver pheasant. Bechstein, St. Hilaire.

The turkey. Bechstein.

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* Article "Hermaphroditism," "Cyc. of Anat."

The pea-hen. Hunter, Jameson.
The partridge. Montagu, Yarrell.
The bustard (*Otis tarda*). Tiedmann.
The American pelican. Catesby.
In the wild and domestic duck. Tiedmann, Rumball.
In the cuckoo. Payrandeau.
In the cotinga. Dufresne.
The chaffinch, by Prevost.
The bunting, by Blumenbach.

The majority of these cases are taken from Simpson's article, before mentioned, and that author gives full references to all the examples quoted by him; and he further states that Rumball, in Home's "Comp. Anatomy," vol. iii., p. 330, mentions that he had seen an old duck which had assumed the male plumage attempt sexual connection with another female.

The various names of illustrious observers who testify to the actual occurrence of this remarkable change place it beyond all question, and it may be stated that there is scarcely a gamekeeper of any experience who has not noted it in many instances and in several species of birds.

In connection with atrophied and degenerated ovary should be mentioned a curious case recorded by Bomare ("Journ. de Phys.," tom. iv., p. 506), in which a hind with a degenerated ovary had developed a horn on the side of the head corresponding to the diseased ovary. This coincides with the observation of Russell, who found that when he removed one testicle from a deer, the horn on the opposite was the more developed of the two. Female deer have been observed to develop horns at puberty, like a stag, and such animals are generally observed to be barren, probably on account of some congenital or acquired morbid condition of the ovaries. In old age, after the period of reproduction has passed, female deer have been known to acquire horns, in a more or less perfect degree, like those of the male.

Parasitism.—Few conditions are more potent in bringing about atrophy and disappearance of organs than parasitism. It comes about, as Ray Lankester forcibly puts it, in the same way "as an active healthy man sometimes degenerates when he becomes suddenly possessed of a fortune; or as Rome degenerated when possessed of the riches of the ancient world."

Sacculina (Fig. 16) is an extreme example of this process. This form infests hermit crabs, and is a mere sac filled with eggs. In the adult state the long, slender, root-like processes subserve the purpose of absorbing nourishment from the juices of its host, yet in its early condition it had the form of the animal shown in Fig. 17.

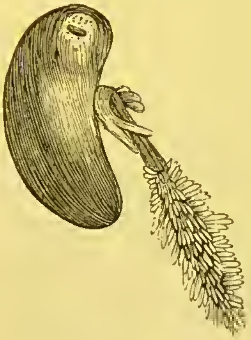

FIG. 16.
SACCULINA IN ITS PARASITIC FORM.
(After Claus.)

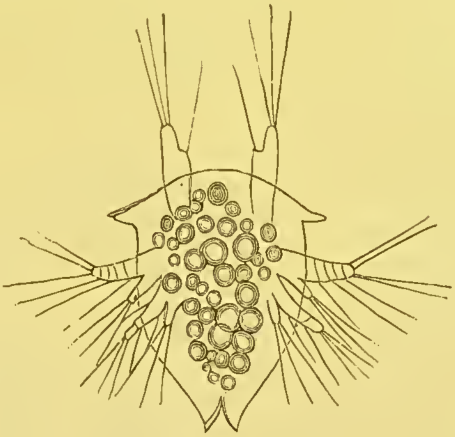

FIG. 17.
ITS NAUPLIUS OR FREE STAGE.
(After Claus.)

Lernæocera furnishes a similar example. In its early childhood it also enjoyed a nauplius-like existence; but in the adult condition it is found attached to the gills of fishes, has lost its legs, and become an elongated worm-like creature such as is represented in Fig. 18.

The small cyclops-like males lead an independent life, and swim freely about by means of their four pair of swimming feet. The females do not become parasitic until after copulation; then they undergo retrogressive changes.

The cestoda, or tapeworms, furnish similar examples. Doubtless, in the six-hooked embryo-form they at one time led a more or less free existence, until parasitism introduced profound modifications in their organization. Cuvier originally placed the lerneans among the intestinal worms. Nordmann showed, upon embryological evidence, that they were crustaceans.

The ascidians furnish us with a good example of atrophy from simple loss of function, as distinct from abrogation of function. I feel no hesitation in putting this case before the reader, because no less an authority than Professor Ray Lankester * has chosen the same animal to illustrate "degeneration." It is necessary to note, however, that Lankester uses the term in a much broader sense than the pathologist; the latter limits the term degeneration to signify degradation of *tissue*, whereas the biologist applies it to retrogression generally, but of no tissue in particular.

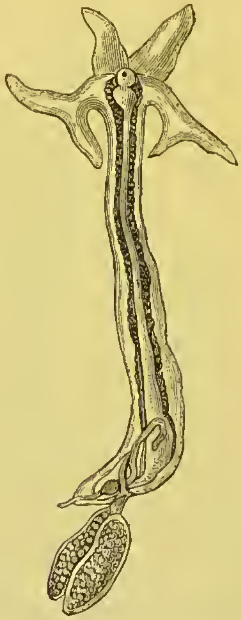

FIG. 18.—LERNÆOCERA IN ITS PARASITIC OR DEGENERATE STAGE. (After Lankester.)

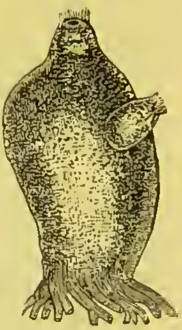

FIG. 19.
AN ADULT ASCIDIAN.

The ascidians are marine animals which are found encrusting rocks, stones, and weeds on the sea-bottom. Sometimes they are solitary, but they often occur combined in masses. An adult form is represented in Fig. 19. In general appearance it reminds one of a tough leathern bottle with two openings; water enters at one aperture and leaves at the other. The young of some of these ascidians has a totally different form; indeed, it resembles the tadpole of a frog, not only in external configuration, but also in its internal organization (*vide* Fig. 20).

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* "Degeneration." An address before the Brit. Association, Sheffield, 1880.

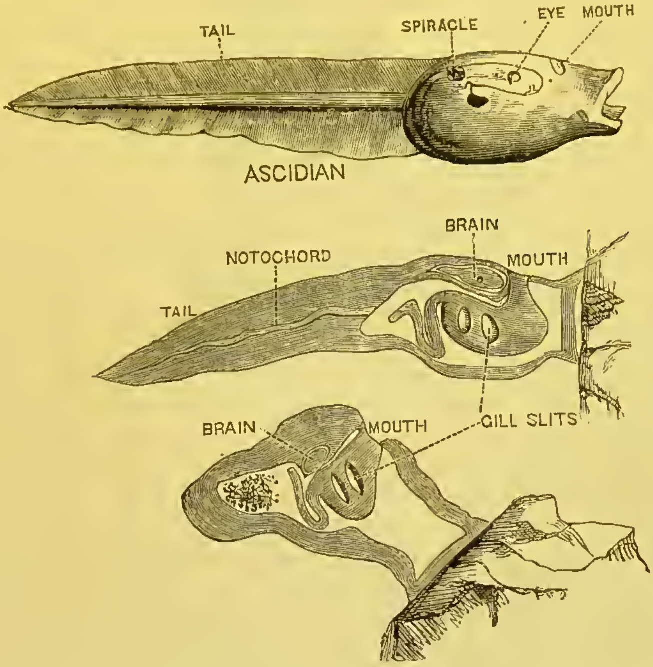

FIG. 20.—VARIOUS STAGES IN THE LIFE-HISTORY OF AN ASCIDIAN. (After Lankester.)

After existing in a free state for some time, the young ascidian fixes itself to a stone by its head; the tail, with the notochord and nervous axis, atrophies, the body changes its shape, the brain remains small and undeveloped, and the eyes disappear. Finally the animal increases in size, its outer case becomes tough and leather-like, and it assumes the appearance shown in Fig. 19.

The internal organization of the adult animal is represented in Fig. 21.

The sequence of events in such cases, occurring in mammals, may be narrated as follows:—

(1) Loss of function, either from inability of performance or loss of necessity.

(2) This leads to diminution in the nutritive supply, for the vascular mechanism is so wonderfully arranged, that where function is at its best, there the supply of nutrient fluid is at a maximum.

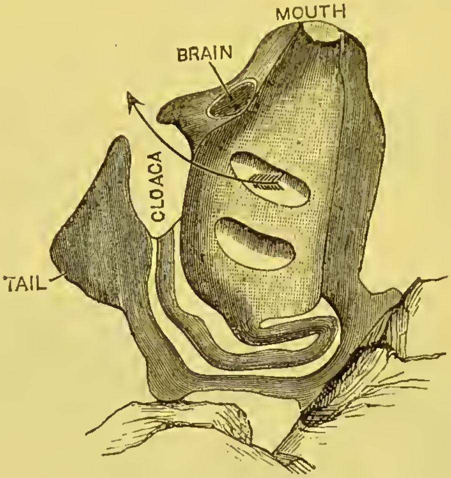

Fig. 21.—Internal Organization of an Adult Ascidian. (After Lankester.)

(3) The quality of protoplasm is dependent on abundant supply of oxygenated blood. Those tissues which play the highest parts in nature—nervous, muscular, and the like—cannot exist as such except under the above conditions; hence, if the nutrient fluid supplied them is deficient in quantity or quality, atrophy is the result. If this extends beyond certain limits, recovery is impossible.

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CHAPTER III.

THE EFFECTS OF CONTINUOUS PRESSURE.

It has long been one of the commonplace facts of pathology that intermittent pressure leads to hypertrophy, but continuous pressure leads to absorption and atrophy. A good example of this form of atrophy came under observation in an old man who, many years before his death, suffered the loss of a portion of the hard palate on account of syphilitic ulceration. The original defect was small; but it annoyed the man by permitting food and liquids to pass into the nasal fossæ. To remedy this, he constructed an obturator of linen rags wound round a piece of wood. The pressure of this crude instrument caused absorption of the hard palate, rendering necessary an increase in the size of the obturator to make it efficient. This treatment was pursued for many years until the greater portion of the hard palate, with the alveolar ridges of the upper maxillæ, the vomer, a considerable portion of the perpendicular plate of the ethmoid and some of its lateral masses, the walls of the antrum, the left lachrymal bone, and the under surface of the body of the sphenoid had suffered atrophy. It is curious to note that the structure which has suffered least is the triangular cartilage of the nose; yet the mucous membrane over the parts is perfectly normal—there is no trace of ulceration anywhere. A somewhat similar case is reported by Sir James Paget in his "Lectures on Surgical Pathology," 4th edition, p. 67.

The curiously curved tusks of the babirussa afford another instance. In confinement these tusks get distorted and grow towards the middle line of the skull; atrophy of the bone arises as a result of pressure; the teeth enter the brain and kill the animal. The horns of oxen occasionally grow in the same way.

Hydatid cysts in the cranial cavity of animals, particularly sheep, lead to serious atrophy of the skull bones that they become thinned and perforated by the enlarging cyst. This disease is a common one among sheep, and is recognized under a variety of names, such as *sturdy*, *gid*, *turnsick*, *staggers*, and the like, many of the names referring to the peculiar rotatory phenomena symptomatic of the presence of these cysts within the cranial cavity. The essential charâcter of the affection consists in the presence in the sheep's brain of *cœnurus cerebralis*, which represents the larval stage of *tænia cœnurus*, one form of tapeworm infesting dogs. For the elucidation of the connection between the larva and the mature tænia we are indebted to Küchenmeister. This investigator fed dogs on hydatids from the brains of *sturdy* sheep; as a result, they became affected with *tænia cœnurus*. In the converse experiments, lambs were fed on mature segments, the proglottides, of tænia, and in about fourteen days symptoms of staggers appeared. The experiments have been repeated by other investigators, and Küchenmeister's observations confirmed. It is curious that although these cysts may develop in other organs of the body—*e.g.*, the lungs, heart, etc.—yet they seem to become abortive; but in the cortical substance of the brain they flourish. In the ordinary course of events, the mode by which sheep become affected is this:—A dog, the subject of *tænia cœnurus*, distributes the ova about the pastures; the ova are swallowed by the sheep whilst grazing or drinking. When they reach the stomach, the egg covering is dissolved by the gastric juice, and the small six-hooked embryo escapes, bores its way into the blood-vessels, and is carried to various parts of the body, but with especial frequency lodge in the brain. After resting here for a time they assume a polycephalous condition.

When they first attain the bladder-worm state, the cysts are usually of the size of a pin's head. In this condition they are thin transparent cysts, consisting of two layers, an endocyst and an ectocyst. The inner layer has growing from its wall minute dots, which are the heads of the hydatids. The fluid contents of the cysts are clear and pellucid, specific gravity slightly above that of water, and faintly alkaline, containing, among other salts, chloride of sodium.

The cyst, as it lies in the brain, becomes surrounded by connective tissue, the result of the irritation its presence induces, and as it increases in size, the pressure-symptoms become manifest, leading to absorption of the brain and walls of the cranium, which often become perforated. This is more likely to happen if several cœnuri be present. Dr. Cobbold refers to an example in Leuckart's collection, where a cœnurus occupied the spinal canal, the cyst being upwards of a foot in length. The same observer also has recorded the existence of a form of cœnurus, slightly different from that found in the sheep, which he discovered in a lemur from Madagascar. In this case it infested the lungs and liver, and had produced atrophy of these organs on account of pressure.*

The museum of the Royal College of Surgeons, London, possesses some exquisite examples of the effects induced by the pressure of these cysts on the brain and crania of sheep.

Few tissues can resist atrophy when exposed to continuous pressure. Thus, in the case of a man who had an aneurism of the internal carotid artery, the corresponding portion of the cerebral hemisphere was hollowed out into a large cavity reaching from the base of the brain to the upper level of the corpus striatum; the roots of the olfactory nerve were atrophied, and the body of the sphenoid bone was hollowed out by the pressure of the aneurism.

In another instance a horse was thrown for the purpose of a slight operation. When the animal was endeavouring to regain the standing position, a loud snap was heard, and it fell helpless. A large aneurism had formed on the posterior aorta, its pressure had hollowed out two of the lumbar vertebræ, which had snapped in twain when the horse attempted to rise.

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* "Entozoa," chap. ix. "Cestoda," 1864.

There are few situations in the body where the disastrous effects of pressure are more manifest than in the central nervous system. In the spinal cord, for instance, the pressure of a tumour, exostosis, or the like, leads often to complete paraplegia. The most curious examples are those singular tumours known as psammomata, or sand tumours (see chapter xvii).

Sir James Paget, in his "Surgical Pathology," refers to a specimen in the museum of St. Bartholomew's Hospital, where an enchondroma arose from the head of a rib, passed through an intervertebral foramen, and spread widely in the spinal canal, compressed the cord, and produced paralysis of the lower limbs and pelvic organs.

Among other rare causes must be included those exostoses, or ecchondroses, usually of small size, springing from the strip of cartilage lying in the basilar suture. Being in close association with the medulla, such growths soon end fatally.*

John Reid has recorded a case where an exostosis grew from the back of the odontoid process, projected into the spinal canal the third of an inch, and compressed the medulla immediately below the decussation of the pyramids, killing the patient ("Edinburgh Medical Journal," 1843).

Some of the most impressive instances of instantaneous death are those due to the sudden rupture of the transverse ligament, allowing the odontoid process to spit the most vital point of the cerebro-spinal axis.

These cases, however, do not always end quite so suddenly, as the following case will serve to show. It occasionally happens that in consequence of disease at the occipito-atlantal or atlo-axoid articulations, the atlas becomes gradually dislocated, and finally ankylosed to the occipital bone or axis, perhaps to both. In this way the cord is slowly compressed, as the atlas slides from its normal position. When this compression acts slowly, the cord seems to accommodate itself to the narrowed space, and severe symptoms are often absent for a long time. Several interesting examples of this form of compression are mentioned in surgical literature (see especially Paget and Shaw, "Trans. Med. and Chir. Soc.," vol. xxxi.).

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* Virchow, "Entwicklung des Schadelgrundes," 1857.

A similar case came under my observation in a tiger which had lived in confinement in this country for six years. Many months before its death it was noticed to drag its hind limbs rather than to walk; by degrees this weakness manifested itself as paralysis, until at last the tiger became completely paraplegic, and died.

At the post-mortem examination it was noted, on removing the skull, that the articular surfaces of the atlas and axis were abnormal, and dissection revealed an old fracture of the atlas. This bone had been broken through the anterior and posterior arch, so that it had been separated into two lateral halves. The fracture had failed to unite except by means of fibrous tissue. There was abundant evidence of inflammation, and on either side of the line of fracture there was a large amount of superfluous tissue of repair. The inflammation had led to softening of the transverse ligament, which had gradually yielded, so as to permit the odontoid process of the axis to press dorsally and nip the medulla. In addition to the displacement, there were nodules of calcified tissue projecting into the canal from the injured portions of the atlas, which assisted still further to diminish its lumen. The space for the passage of the cord had become so narrowed that it would not admit the tip of the little finger. The condition was quite sufficient to account for the slow but progressive character of the paraplegia.

Careful inquiries failed to elicit any information likely to shed light on the cause of the original injury. Such a case as this is by no means unique. I have seen similar specimens in a horse, a cow, and in an ichneumon. In the last case the atlas was dislocated forwards and laterally, becoming ankylosed to the occipital bone; on examining the foramen magnum it was evident that some compression of the medulla must have taken place when the animal was alive.*

The museum of the Royal College of Surgeons, London, possesses a skeleton of a Beluga, or white whale, in whom the atlas had been dislocated, during life, from its articulation. In consequence, the aperture for the transmission of the spinal cord was narrowed, so that only a chink, scarcely three-quarters of an inch in its greatest transverse diameter remains. The dislocation was in all probability traumatic.*

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* "Path. Soc. Trans.," vol. xxxvii.

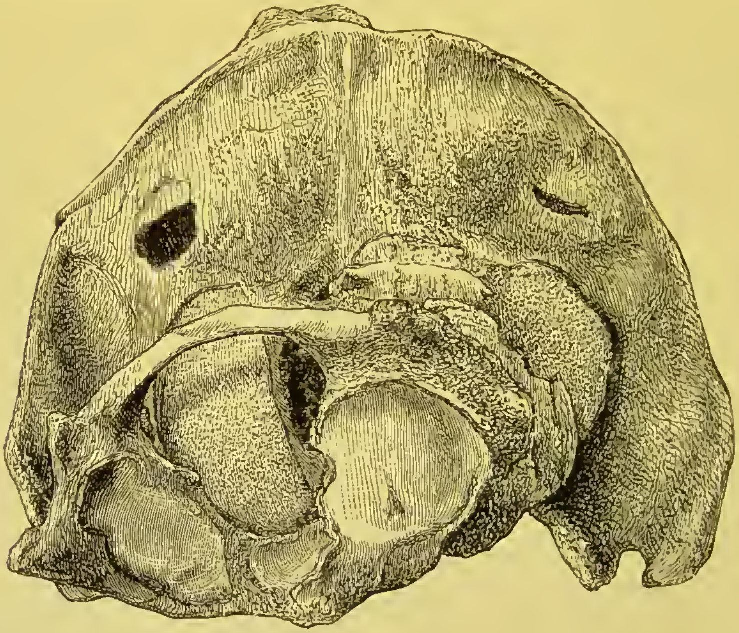

FIG. 22.—OCCIPUT OF BELUGA SHOWING THE DISLOCATED ATLAS. (After Flower.)

Mr. Lane has drawn attention to a form of spinal deformity which he considers to arise from pressure exerted by weights carried upon the head. The effect is to lead to slight lateral curvature of the cervical and dorsal spine. In the neck the intervertebral discs become destroyed on the concave side of the curve, and the corresponding portions of the bodies of the vertebræ are diminished in size, becoming wedge-shaped. If the intervertebral discs disappear, the bodies of the vertebræ and transverse processes may become ankylosed.

Attention must now be given to some singular examples of slow compression of the cord. It has long been known that monkeys, when in confinement in this country, die often with symptoms of more or less complete paraplegia, for which it was difficult to find any satisfactory explanation.

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* Prof. Flower, "Proc. Zool. Soc.," 1879.

† "Med.-Chir. Soc. Trans.," vol. lxvii.

The "Journal de Zoologie" for 1875 (iv., p. 272) contains an interesting article by Paul Gervais, entitled, "De l'hyperostoze chez l'homme et les animaux." Among the specimens there figured is a vertebra from an animal named *Pachyacanthus*, dug up near Vienna. It is a singular specimen, and shows a condition which is very rarely met with, viz., general obliteration of the spinal canal, due to overgrowth of bone. This supplied the hint, and I divided the spinal column in all rickety monkeys. This is what was found:—The general overgrowth and softening of bone so common throughout the skeleton had not spared the vertebræ with their various processes, but they had enlarged and encroached upon the spinal canal, and thus exercised general slow compression upon the spinal cord. When the creature stood, the pressure of the superincumbent weight would cause the vertebral bodies to bulge and compress still more the spinal cord and the nerves as they emerge from the various intervertebral foramina. I am not aware of any recorded cases of such general narrowing of the neural canal; and it is easy to explain why it has been overlooked, for it is usual to expose the cord by removal of the vertebral arches, thus destroying the relative size of the cord to the spinal canal; whereas if a transverse section of the column be made with the cord *in situ*, the change is obvious. The cord and nerves, when examined microscopically, exhibit all the changes found in the grey and white matter when the cord has been compressed from other causes, such as cancer, tumour, vertebral caries, etc.

A vertebra of *Pachyacanthus*, showing its narrowed canal, is represented in Fig. 23; and a section through a vertebra, showing the compressed cord *in situ*, from a monkey, in Fig. 24.

This gradual compression of the cord occurs in other animals, such as tigers, lambs, bears, and others. In the case of animals about puberty, the pressure on the cord is not due so much to softening of the bones, as to rickety changes occurring at the epiphysial plates, which at this period of a mammal's life are developing rapidly. In the accompanying drawing (Fig. 25) this mode of pressure is illustrated.

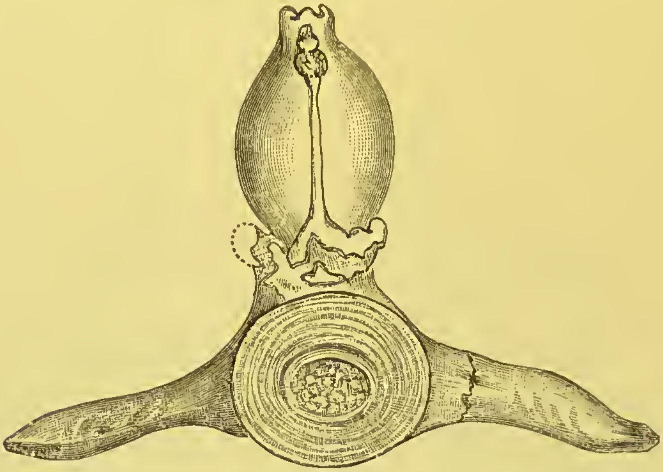

FIG. 23.—VERTEBRA OF PACHYACANTHUS.
Showing the narrowed spinal canal. (After Gervais, *l.c.*)

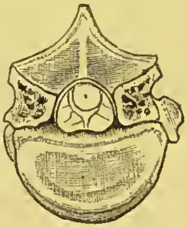

FIG. 24.—TRANSVERSE SECTION OF THE VERTEBRAL COLUMN WITH THE CORD *in situ*.
To show the mode by which the cord is compressed by overgrowth of the surrounding bone. From a monkey.

Principal Robertson has since shown that it is to precisely similar lesions that "weak back," so common in lambs reared on lands dressed with caustic lime, is due, viz., under-bulging of the discs owing to increased development of spongoid tissue, so characteristic of rickets. These conditions shed some light on one of the clinical symptoms exhibited by that remarkable disease mollities ossium, when present in the human subject. Pain is, in most cases, one of the leading symptoms in this affection. As a rule, these pains, often of an agonizing character, commence in the neighbourhood of

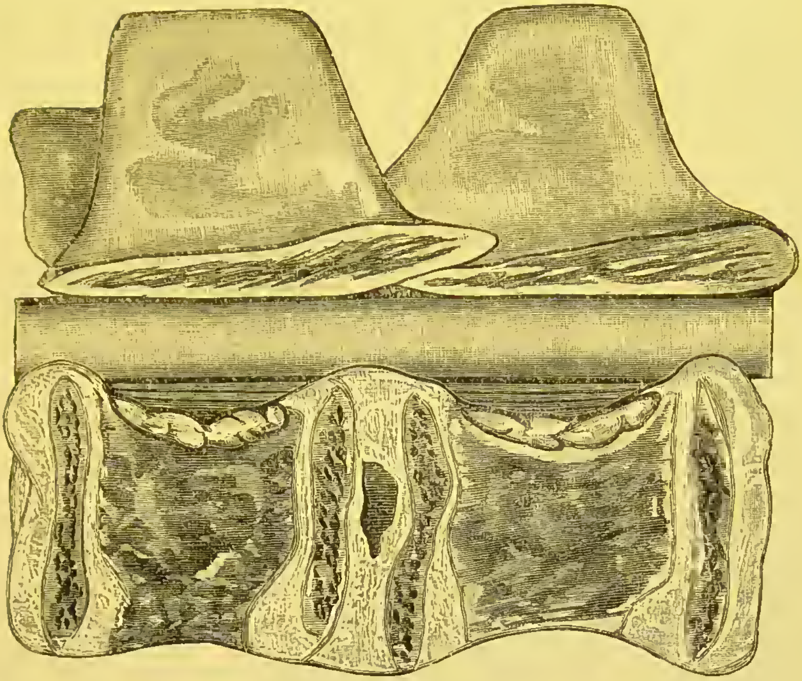

FIG. 25.—A LONGITUDINAL SECTION THROUGH THE LAST DORSAL AND FIRST LUMBAR VERTEBRÆ OF A LION AFFECTED WITH "LATE RICKETS."

It shows the proliferation of the tissue in the neighbourhood of the epiphysial plate, and the abnormal size of the intervertebral disc, bulging into the neural canal and compressing the spinal cord.

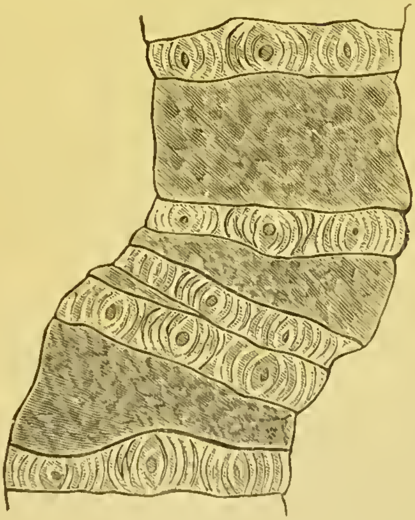

FIG. 26.—SECTION THROUGH THE DORSAL VERTEBRÆ OF A WOMAN AFFECTED WITH MOLLITIES OSSIUM.

To show absorption of the bones. Two discs have come into apposition in consequence.

the pelvis, and extend to the legs, gradually spreading thence over the body. In all cases where the disease has existed any length of time, softening of the vertebral column has been noted. Not only are the vertebræ softened, but the pressure of the superincumbent mass leads to their absorption. In the specimen from which Fig. 26 was taken, the bodies of some of the vertebræ have disappeared, and the intervertebral discs have come into contact. Now, during this process, the nerves and nerve-roots, as they pass to the intervertebral foramina, must get seriously pressed upon and squeezed; this alone is quite sufficient to account for the dreadful pains experienced in this terrible malady.

One other evil effect of this interference of the cord in rickets must be mentioned. It occasionally happens, especially in the baboons, that when the paraplegia becomes complete, the animal is prevented from using its feet and legs; under these circumstances the nails grow unusually long (Fig. 27), as in old bedridden men and women. It is well known that in dogs and other carnivorous animals the claws sometimes grow excessively, and, forming a curve, press into and cause absorption of the soft tissues, thus giving rise to considerable pain. They remind us of the Fakir's finger-nails.

An example somewhat resembling this has been related to me by Mr. Adams, where, in a case of Dupuytren's contraction, a finger became so contracted and doubled into the palm, that the pressure exerted by the tip of the digit had caused absorption of the tissues of the palm, so as to form a distinct cavity. Such a severe case as this must, however, be very rare indeed.

Muscular tissue is exceedingly prone to atrophy when subjected to pressure. This is well exemplified in flexions of the uterus, for that wall of the organ which is pressed upon by the fundus, in acute flexion of long standing, is sure to exhibit considerable thinning. This is equally true of animals —monkeys, deer, goats, and the like—as it is of the human female.

Such atrophy is not limited to organs composed of involuntary muscle-fibre, but may affect voluntary muscle;

this may be well seen when a muscle becomes stretched by the growth of a tumour, a cyst, or even by callus.

As an example of pressure causing atrophy of a muscle, the following may be mentioned:—A small monkey had a hydatid cyst (6 in. by 3) developed in the peritoneum; this had pressed the liver to one side, and, pushing up the diaphragm, had caused this structure to atrophy, the cyst making its way into the right pleura.

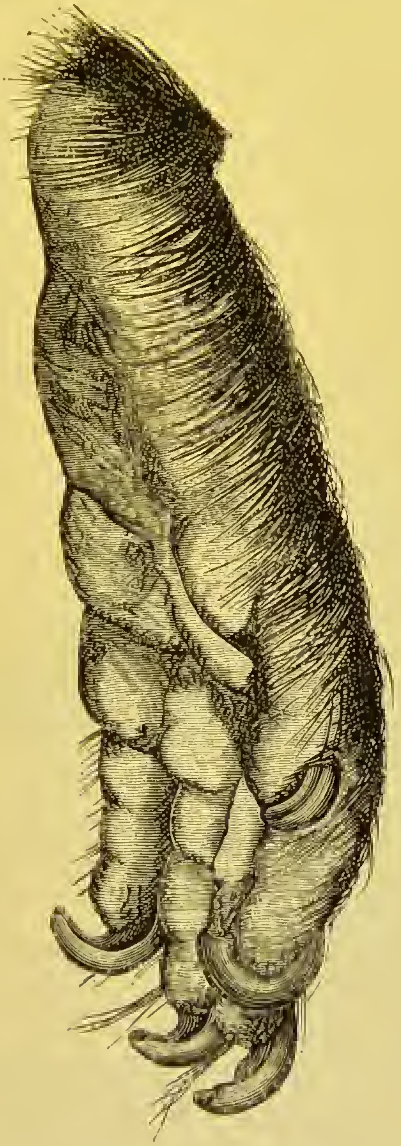

FIG. 27.—FOOT OF A BABOON.

The nails have grown abnormally long in consequence of paraplegia.

The third variety of muscle-fibre, known as the cardiac, is not exempt from this atrophying process when subjected to pressure. The organ concerned is so important to the life of the animal that the case is worth describing.

One of the most frequent morbid lesions found in post-mortem inspections is a curious white patch on the anterior wall of the heart, and usually recognized as the "milk-white patch." This is generally believed to be the result of pressure. It is by no means confined to man; I have found it in birds (Rhea), in monkeys, and other animals, as the direct result of pressure of a rickety thorax on the heart.

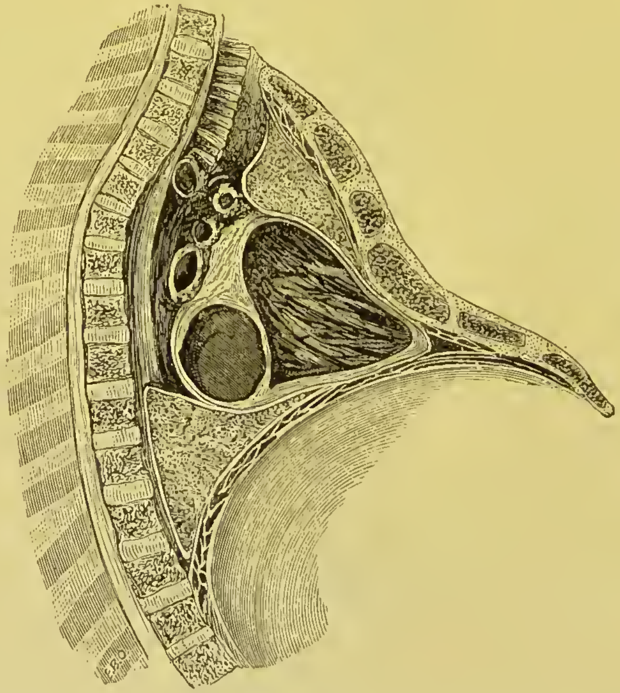

FIG. 28.—SAGITTAL SECTION THROUGH THORAX OF RICKETY MONKEY. Showing "flexion" of the heart.

When conducting dissections of rickety monkeys, my attention has often been arrested by a curious appearance presented by the right ventricle; in many cases it is so exceedingly thin that the blood in the ventricular cavity can be seen through it, giving to the tissue a peculiar purple tint, exactly like that of a venous nævus. The only way to account for this extreme thinning was that it might be due to pressure. Accordingly a rickety monkey was selected, frozen, and bisected sagittally, as represented in Fig. 28, when it was clearly seen that, as a consequence of spinal curvature (the cat's back of rickets), a curving of the sternum had resulted, leading to a "knuckling" of this bone on its inner aspect, which pressed upon the heart. This important organ was squeezed between the sternum in front and the spine behind. As a result of this continued pressure atrophy resulted to a very dangerous extent. This mode of pressure is common in young monkeys.

While dealing with pressure, it must be pointed out that to produce the effects described above, the pressure must be not only continuous, but direct. The indirect effects of pressure may lead to curious conditions.

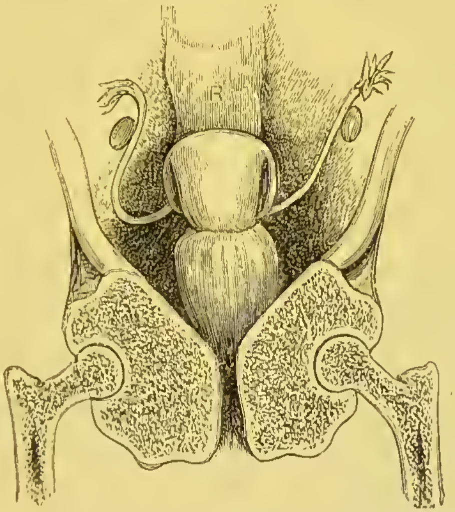

FIG. 29.—RICKETY PELVIS OF MONKEY.
Showing the mode of displacement of uterus, and its subsequent retroflexion.

In Fig. 29 is represented a vertical transverse section through the pelvis of a rickety monkey. The bones were so soft that they yielded to the pressure of the body, transmitted to them through the head of the femora, to such an extent that the opposite sides of the pelvis are in contact, and have nipped the vagina and urethra between them, leading to flexion of the uterus, obstruction of the urine, and consequent hypertrophy of the muscular tissue of the bladder.

Another condition, the indirect result of pressure, is occasionally seen in the lungs of monkeys, and is of some interest, as it frequently brings about a fatal result.

The pleura of quadrumana is a favourite situation for hydatid cysts to develop. The cysts are most common on the costal pleura; in this position two distinct courses are open to them. If so placed that they do not come into contact with the bronchus, the cysts attain a large size and compress the lung, producing atrophy and eventually death. In two cases the cyst has been no larger than a nut, and yet caused death, for it was so placed on the pleura that it compressed the bronchus of the right lung which transmitted air to the two upper lobes, producing thereby complete atelectasis of those lobes (Fig. 30).

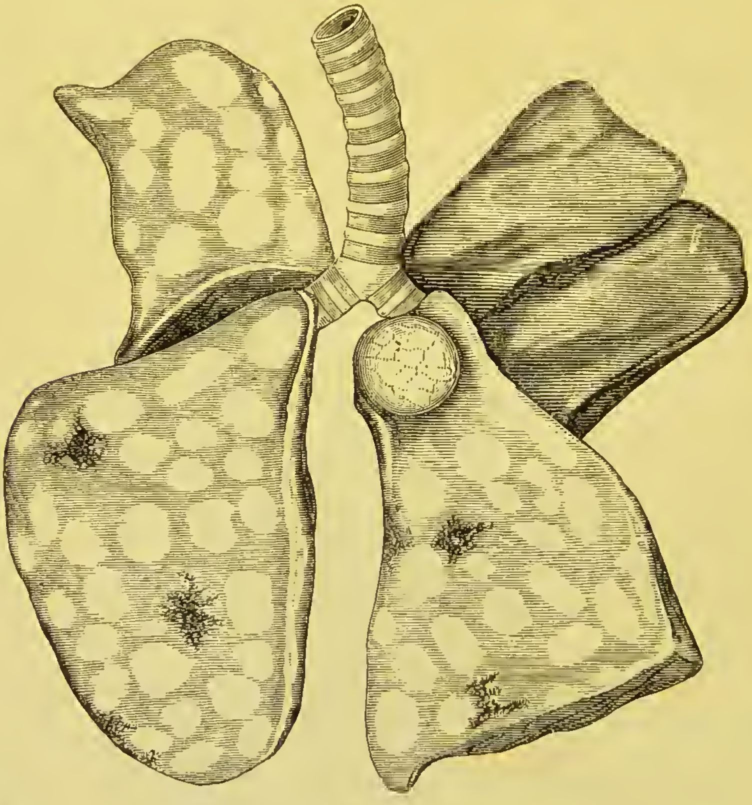

FIG. 30.—LUNGS OF A LEMUR.

A hydatid cyst growing from the pleura had compressed the right bronchus, and led to collapse of the two upper lobes of the lung.

Some of the indirect effects of pressure are very interesting, and, from a clinical point of view, important.

A few examples will suffice. Mr. Wardrop, in his edition of "Baillie's Works," vol. ii., p. 315, records, in a foot-note, the case of a man who had suffered absorption of both testicles. The man died of aneurism of the aorta, which had obliterated both spermatic arteries. The pressure of an ill-fitting truss has been known to produce atrophy of the testicle from interference with the vessels in the spermatic cord.

In cases of long-continued intestinal obstruction originating near the rectum, the pressure of the retained fæces leads to ulceration in the cæcum, and occasionally to perforation and death.

Among some of the more interesting examples of the injurious effects of pressure must be mentioned the cases of compression of nerve-trunks, such as the seventh cranial nerve (facial) in its course through the Fallopian canal. This nerve in man is often permanently paralysed in cases where neoplasms (exostoses) grow from the petrous bone. I have seen similar cases in horses, in whom the signs of facial paralysis are as obvious as they are in man.

The nerve-cords of the limbs are frequently paralysed as a result of pressure either by the fractured bones, or involved in the callus thrown out for their repair. They may also be compressed by morbid growths, or external pressure, as in the well-known crutch-palsy. In some respects similar to crutch-palsy must be mentioned the following variety, described by M. Bachon. It is a curious form of pressure-palsy to which the water-carriers of the town of Rennes are liable. In this instance pressure upon the radial nerve (*Ang.* musculo-spiral), exerted by the water-vessels consequent upon the position of the arm in carrying them, leads often to wrist-drop (*vide* Weir Mitchell, "Injuries of Nerves," p. 132).

Many instances of temporary paralyses of the arm or leg due to malposition of these limbs during sleep have been recorded. Sleeping with the head resting upon the arm is a frequent cause of temporary paralysis.

Pressure of instruments during difficult parturition has been known to bring about facial palsy, and it is recognized as one of the causes of congenital ptosis, which may in some cases be permanent.

Principal Robertson has favoured me with the following details of a case which was under his care :—

A horse had sustained fracture of the sacrum, causing the hæmorrhoidal nerve to be nipped between the fragments. This led to paralysis of the muscle which elevated the tail, and also the anus. For the rest of the animal's life it never raised its tail, and its rectum required the manipulation of the stableman for its evacuation.

Among the more subtile forms of paralysis from pressure are those cases where, after exposure to a draught of cold air, the facial or fifth nerve, or some of the branches which run through osseous canals, become paralysed. This is due to the circumstance that inflammation is induced, fluid exudes into the sheath of the nerve, the rigid bony walls cannot yield, hence the delicate tissues of the nerve are compressed.

The effects of continued pressure in producing absorption are observable as natural processes in many parts of the bodies of higher mammals.

In the vascular system, large arterial trunks, running parallel, tend to fuse and form single vessels ; even the heart arises primarily by the fusion of two tubes. The abdominal aorta is originally double, but subsequent fusion disguises its former duplicity. The basilar artery is a case in point. This artery, like the aorta, is occasionally found divided by a longitudinal septum. In a chimpanzee I once found the anterior cerebral arteries fused into a single trunk.

The duct of a compound gland arises by fusion of many smaller ducts. This is strikingly illustrated by the ureter, for at its commencement it is often double, and even treble, and three ureters have been known to leave the kidney, each separately entering the bladder.

The brain offers some beautiful examples, for the fornix, septum lucidum, and middle commissure of the third ventricle are merely remnants of the walls of the vesicles, left unabsorbed by the general pressure exerted by the dorsally extending cerebral hemispheres on the three primary vesicles. The fornix is all that remains of the floor of the cerebral vesicles, and the grey commissure represents the roof of the first primary vesicle. The velum interpositum was at one time on the outside of the brain, but the overlapping cerebral vesicles made it an internal structure, thus burying its superficial veins between two layers of pia mater. The skull presents many examples, but the consideration of this subject will be deferred until we deal with neoplasms.

Ulceration from Pressure.—In all the examples of atrophy of parts as a result of continuous pressure we have considered, the absorption or removal of those parts of the organ pressed upon has been effected without any evidence of ulceration. A good deal of latitude is generally allowed in the use of the term "ulceration," and as a consequence it often comes to be employed vaguely. In this work it will be used in the following sense:—

Ulceration is the process by which the organism rids itself of dead and noxious tissues. An "ulcer" is the surface of the living tissues which is exposed after removal of the dead tissue. Ulceration is an *active* process, and the details will be more fully considered in the chapter on Inflammation.

So far as my observations on man and other animals have extended, I have come to the conclusion that pressure on cutaneous and mucous surfaces is exceedingly prone to induce ulceration. The explanation seems to be this:—Skin and mucous membranes are abundantly supplied by means of a rich capillary network; when the part is submitted, for any undue length of time, to pressure, the tissues are, during that time, deprived of blood, and die. The dead or necrosed tissue is now removed piecemeal by the leucocytes, and other parts separate as larger or smaller sloughs, and an ulcer is the result. If compared with other forms of necrosis, we may say that gangrene arises as a result of obstruction in an artery or a vein; whereas the necrosis preceding ulceration is due to obstruction from pressure or thrombosis of the capillaries of the part. In the case of ulcers, so common on the legs of the old and enfeebled, we really have to deal with a limited necrosis, due to the thrombosis of minute venules, caused by hindrance to the free escape of blood from the area, consequent on the venous stagnation.

In ulcerations due to pressure, it is the offending body causing death of the part by preventing capillary circulation that brings about the sloughing. This may be well studied in the male salmon. After the second year, or when the fish commences to breed, a knob appears at the end of the lower jaw. This knob yearly increases in size at the breeding season. In some cases this knob, by its pressure, causes ulceration of the mucous membrane covering the palate.

The following example drawn from frogs may be interesting:—

During spring the male frog, *Rana esculenta*, may be readily distinguished from the female by the fact that a callous pad is formed on the radial side of the manus, whereby the male may firmly grasp the female. In many cases it has happened that the pressure of this rough pad over the coracoid of the female has led to ulceration of the integument and exposure of the bone, in cases where copulation has been maintained for two days or more.

It is well known that prolonged dorsal decubitus will produce the form of ulceration known as bed-sores, particularly in cases of paraplegia; in these instances the prolonged pressure leads to anæmia of the tissue, and consequent necrosis ending in ulceration.

In the same way pressure of a gall-stone in the bile-duct, or a mass of hardened fæces in the rectum, may produce ulceration. In one case, a tiger had contracted the curious habit of licking the sawdust from the floor of his cage, with the result that a hard ball of this indigestible substance collected in the rectum, measuring six inches in length, and eight inches in girth. When the animal died, a ring of ulceration had formed around the gut, where it had been pressed upon by this singular mass. Very many similar instances of such effects of insoluble substances, when present in the alimentary canal, are recorded as occurring in the human subject.

CHAPTER IV.

THE CORRELATION OF ORGANS.

It is a matter of common observation that when an individual is deprived of vision, his audition becomes in very many cases exceedingly acute, and in many instances the sense of touch becomes heightened, so that by means of tactile sensations, they make themselves acquainted with external surroundings in a manner which frequently borders on the marvellous. In this way a blind person is in a large measure recompensed for his want of eyesight. The reverse of this often obtains. A deaf person, especially if he be young, is often, by acuteness of vision, enabled to meet many of the difficulties which his infirmity necessarily entails.

To such conditions as these the term "correlation of the senses" is applicable; and in much the same way there exists a correlation of organs and structures. In many instances it is so obvious as scarcely to need pointing out. This is more particularly the case in paired organs, and the example of the kidney, described on page 11, well illustrates my meaning.

In the majority of examples of hypertrophy studied by purely human pathologists, atrophy is the primary or causative condition of the enlargement of the correlated organ; but an attempt will be made to demonstrate the reverse of this, viz., hypertrophy the determining cause, atrophy the effect.

Let us now discuss some subtile examples of this remarkable, but very valuable process.

It is a thoroughly established physiological fact that those organs which are in the most constant demand are richly supplied with blood, *e.g.*, the alimentary canal, brain, muscles, etc.; a functional organ may thus be said to be supplied with blood according to the frequency with which it comes into action. Hence it is that function and blood-supply are almost inseparably associated in producing true hypertrophy. This is well demonstrated in the case of the kidneys considered in the chapter on Hypertrophy. The work of purifying the blood had been previously shared by two kidneys; but now the increased work and increased blood-supply affect the remaining organ—it hypertrophies to meet the requirements of the organism. It is impossible to determine whether the increase in the blood-supply is the cause or the effect of the hypertrophy of an organ. Probably both are more or less inseparably associated as causative agents.

A very important feature connected with the enlargement of an artery or arteries supplying hypertrophied organs, is that this leads to a diversion of the nutrient stream, which in most cases reacts to the detriment of some other organs. This is well illustrated in the case of the mesonephros (Wolffian body). For the first few weeks of embryonic life of mammals, this structure is of some size relative to the embryo at that period; but when the metanephros, or permanent kidney, begins to grow, the diversion of the blood-stream in its favour leads eventually to the practically complete disappearance of its rival. This is an exceedingly important matter, because when critically studied it shows most conclusively that hypertrophy of an organ may lead to atrophy of some associated organ. The condition may be studied in the horse.

The metacarpus of the horse is composed of a greatly hypertrophied third metacarpal bone, whilst applied to the posterior lateral edges of this large bone may be seen two rudimentary metacarpals. Each of these bones represents a slender pyramid, with its base upwards and the apex pointing directly downwards. Of the two bones, the internal is thicker than the external, and often the longer of the two. The large bone represents the middle or third metacarpal, whilst its two slender companions correspond to the second and fourth metacarpals of the typical mammalian manus.

Thanks to the labours of Rütimeyer and Marsh, we are now in possession of the palæontological history of the ancestors of our modern horse. The facts on this point, so far as regards the manus, have been admirably summed up by Wiedersheim* as follows:—

The oldest known stem form of the horse is *Eohippus*, which has been found in the Lower Eocene of North America. It possessed four well-developed fingers and the rudiment of a fifth, the thumb. Next we find that the thumb has completely disappeared in *Orohippus* and *Epihippus*, the four remaining fingers persisting. These animals were about the size of a fox, whilst in the Upper Eocene *Mesohippus* had attained the size of a sheep. Here three fingers only were well formed; a fourth merely existed as a rudiment, which in the next form, *Miohippus*, has become yet smaller. In the Pliocene representative, *Protohippus*, the last remnant of a fourth finger disappears, and three only persist. This animal corresponds to the European *Hipparion*, and was of the size of an ass. Another Pliocene form, *Pliohippus*, had the second and fourth fingers extremely rudimentary, the development of the third being alone significant. Lastly, we come to the modern horse, with its peculiarly specialized manus.

The accompanying figures are intended to afford a graphic representation of the preceding facts (Fig. 31).

With such an array of evidence no one would venture to deny that the slender fourth and second metacarpals are rudimentary structures in the true sense and meaning of that term. These bones are often a nuisance to the animal, as they are exceedingly liable to inflame and produce lameness; the disease is known to veterinarians as splent-bone, and often ends in osseous ankylosis between them and the main metacarpal, a condition of things detrimental to the horse for working purposes.

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* "Vergl. Anatomie," vol. i., p. 198.

The history of this foot has been given, for it serves to illustrate a principle—hypertrophy of one structure leading to the atrophy of another; for in this case it seems the most probable view, that gradual increase in the size and functional importance of the third metacarpal bone has led to the abortion of the remaining bones, its original companions, by causing a diversion of the nutrient stream to its own advantage, but to the detriment of the lateral metacarpals.

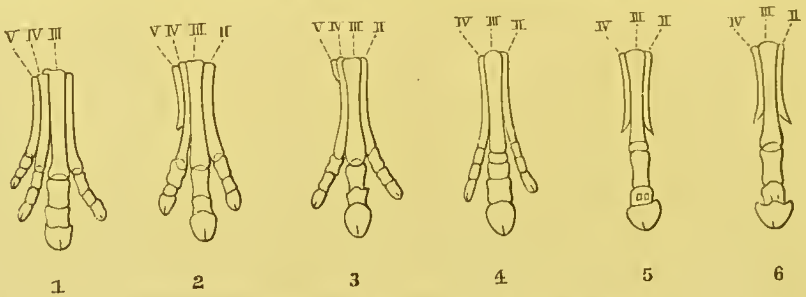
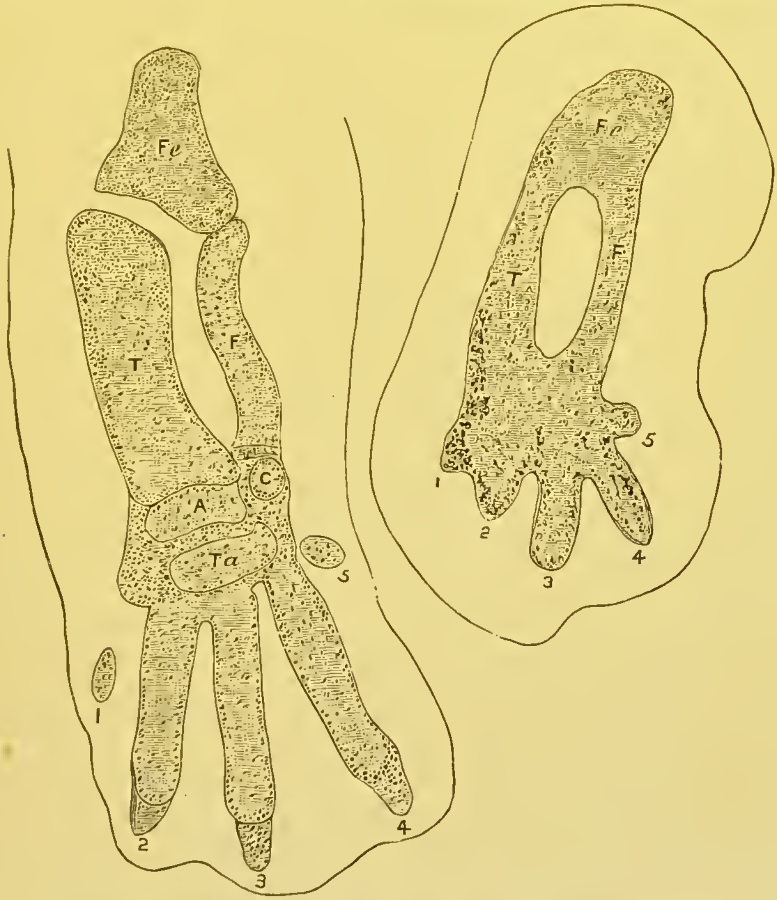


FIG. 31.—A SERIES OF FIGURES TO SHOW THE ANCESTRY OF THE MANUS OF THE MODERN HORSE.

1. *Orohippus* (Eocene). 2. *Mesohippus* (Upper Eocene). 3. *Miohippus* (Miocene). 4. *Protohippus* (Upper Pliocene). 5. *Pliohippus*. 6. *Equus*. (After Wiedersheim.)

We all bear in our legs a similar and equally convincing example of correlation as that seen in the manus of the *Equidæ*. In man, the tibia, as compared with the fibula by weight, is as three to one, as a rule. If sections be made through the leg of a human fœtus at the third month of embryonic life, it will be seen that a transverse section of the fibula is very little smaller than a corresponding section of the tibial shaft. If we examine the condition of the fibula in the leg of an adult bird, such as a fowl, eagle, pheasant, or blackbird, we shall find not only a considerable disproportion between the fibula and tibia in thickness, but also in the matter of length; the fibula falls short of that of the tibia by fully a third.

In the young chick at the fifth day of incubation the proportions of these elements of the limb to each other is exhibited in Fig. 32. The larger figure shows their proportions at the eighth day of incubation, and by the end of the period of incubation the fibula is simply represented by a thin style of bone lying alongside the tibia for the upper two-thirds of its extent, and terminating superiorly in a somewhat enlarged boss of bone, which articulates with the femur.



Figs. 32 and 33.—Dissection of the Leg of a Chick at the Fifth and the Eighth Day of Incubation. (After Johnson.)

Fe, femur; T, tibia; F, fibula; A, astragalus (tibiale); C, os calcis (fibulare); Ta, tarsalia. The numerals refer to the digits.

On looking at the hind limb of the salamander represented in Fig. 34, it will be at once noted that the tibia and fibula in the hind, like the radius and ulna in the fore limb, are of equal size; this arrangement may be looked upon as the normal one. The salamander, like such forms as Menobranchus and Menopoma, spends the greater part of its life in the water, in which element the limbs are used as paddles; and in these cases the fibula is always equal to, or very little less in thickness than the tibia. Later it came about that the descendants of some of these forms changed their mode of life and became semi-aquatic or terrestrial animals, and began to use their limbs for crawling, creeping, and running, habits which led to changes in the bony framework. So far as the leg is concerned it is easy to see that it was advantageous for the weight of the body to be transmitted to the ground by one bone rather than two; hence the bone most used, the tibia, hypertrophied. The enlarged bone demanded increased blood-supply; this led to a diversion of the nutrient stream in favour of the tibia, but to the detriment of the fibula. Nevertheless, so truly does the fibula obey the great law, heredity, that in the fœtus it does to some extent maintain its pristine eminence.

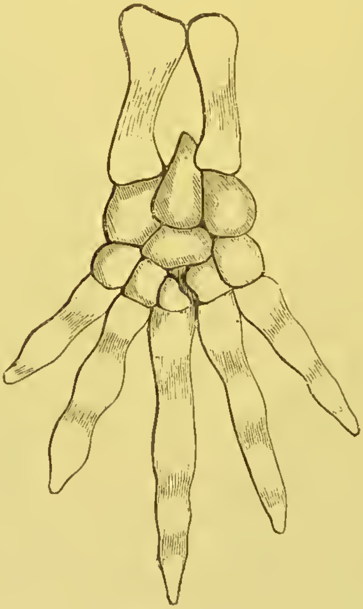


FIG. 34.—LEG OF A SALAMANDER—TIBIA AND FIBULA OF EQUAL SIZE.

As arguments in favour of this view, it is well to remember that in the aquatic mammalia possessing functional hind limbs, *e.g.*, the seals, the fibula bears a much greater proportion to the tibia than in land animals. The muscular system of mammals and birds abounds in many exquisite examples of this beautiful law. One instance must suffice. In the armadillo the digits of the pes are so bound together and incapable of independent movement that the special short flexors of the toes are merely represented by bands of fibrous tissue ; much the same condition exists in the manus. Correlated with this degenerate condition of the short flexors, the plantaris in the hind, and the palmaris longus in the fore limbs, are powerful muscles, and are muscular throughout their whole length, and extend even to the digits, which they serve to flex. In man they are thin insignificant structures, with long tendons, their distal muscle-fibres metamorphosed into plantar and palmar fasciæ.*

I propose now to consider some examples affecting the reproductive organs ; and shall adduce evidence to show that this process is one of the probable causes of division into sexes. Many anatomists are of opinion that hermaphroditism is the primitive condition of the sexual organs.

Hermaphrodites are found in every group of the animal kingdom, but, except in some of the lowest forms (such as *Ctenophora* and *Chrysaora*) among the Cœlenterata, self-fertilization appears to be wholly exceptional, and in those forms in which it occurs the entire process is of very simple character. Concerning this matter Darwin† makes the following important observation :—"Turning for a brief space to animals, various terrestrial species are hermaphrodites, such as land-mollusca and earth-worms; but these all pair. As yet I have not found a single terrestrial animal which can fertilize itself." The rule in hermaphrodites appears to be this :—The male organs in one animal are used to impregnate the female organs of another, or *vice versâ*. Even in the Cestoda, where there are arrangements favourable to self-impregnation, we have no positive evidence that it takes place.

From this arrangement it would easily come to pass that if one animal used the male portions of its reproductive organs more freely than the female parts, they would, as a result of increased function, hypertrophy.

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* *Vide* "Journal of Anat. and Phys.," vol. xix., p. 30.

† "Origin of Species," sixth edition, p. 79.

In the first portion of this chapter I emphasized the fact that any marked degree of hypertrophy in one organ nearly always leads to dwarfing of the correlated organ or sets of organs; hence, in the example considered, the female portions of the hermaphrodite organs remain dwarfed or *in statu quo.* This peculiarity would, in the natural course of events, be transmitted to the offspring, until at last the differentiation attains such a high degree, that unless hypertrophy of one set of organs occurs in each individual, propagation is impeded. Evidence on this point is afforded by the developmental history (ontogeny) of any mammal. Whilst the two sets of reproductive organs, male and female, up to a certain point maintain the same degree of growth, it is impossible to determine the sex of the embryo. As soon as one set begin to enlarge at a greater rate than the other, the sex becomes pronounced. The remaining organs may eventually disappear, or merely exist in such a rudimentary condition as to be discerned only by the most diligent search.

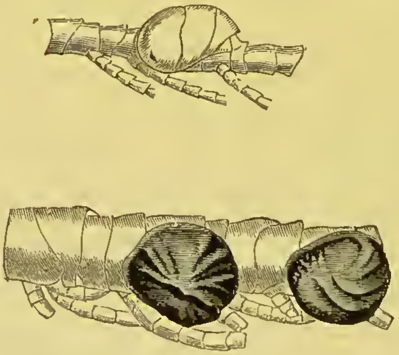

Fig. 35.—Cysts on the Arms of Crinoids, containing *Myzostomida.* (After Von Graff.)

Attention must now be directed to a very remarkable group of invertebrates known as the *Myzostomida.* This genus comprehends certain small animals which are parasitic upon the arms of crinoids (feather-stars). The arms of crinoids, when affected with these forms, present peculiar swellings having the appearance shown in Fig. 35, where the general shape of the cyst containing the parasites is fairly well represented, the general aspect of the cyst reminding one of an oak gall.

In Fig. 36 is represented a ventral and dorsal view of a myzostomum. The body has the form of a flattened oval disc, the surface ciliated, and its margins may be produced into short filamentous processes or cirri. There are also five pairs of non-articulate foot stumps, or parapodia, and nearer the margins are four pairs of suckers. Close to the anterior end of the ventral surface is the mouth, and close to the posterior end is the cloaca.

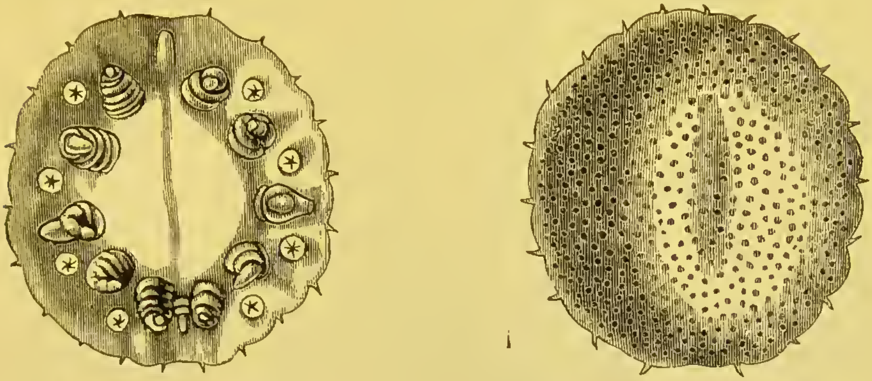

Fig. 36.—A Ventral and Dorsal view of *Myzostoma gigas*. Magnified 5 diameters. (After Von Graff.)

The part to which I wish to draw especial attention is the reproductive system. The female organs consist of a number of ovarian cæca, dorsal in position; they open into the cloaca by a central uterine tube. The testes are usually ventral in position, and ramify on the sides of the stomach; the cæca unite on each side into a spermatic vesicle, which opens to the exterior between the third parapodium and the margin of the body. From this account it will be observed that these parasites are hermaphroditic. The various parts are represented in the accompanying diagram (Fig. 37), where for clearness the male organs have been displayed on one side, the female on the other.

In 1875, Willemoes Suhm suggested that in all probability some of the Myzostomida were diœcious, and discovered to his astonishment that individuals contained in a single cyst either resembled each other in form and size, or were very different, and concluded, without being able to examine the sexual organs, that one had the male organs especially developed, and the other the female organs.

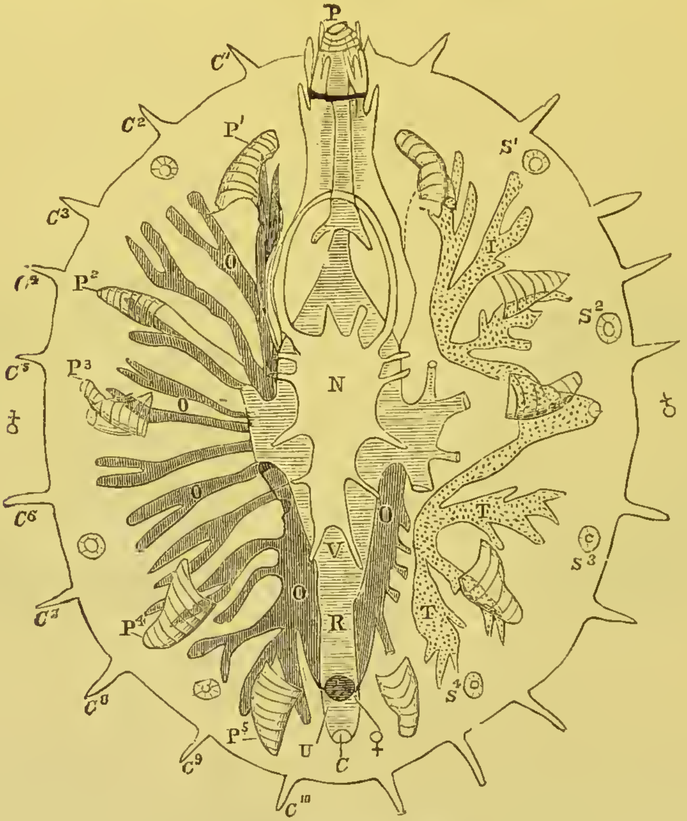

Fig. 37.—A Diagram to represent the Organization of *Myzostomum*. (Modified from Von Graff.)

O, ovary; T, testis; R, rectum; C, cloaca; ♂, male genital pores; P, parapodia; C, cirri; N, ganglion.

Dr. von Graff, in his valuable report on the *Challenger* Myzostomida showed that this is really the case, and that each individual is either male or female; and that in addition the two sexes are totally unlike in appearance, the female being usually 50 to 100 times as large as the male.

Von Graff then adduces evidence to show that the diœcious forms among *Myzostoma cysticolum*, *M. tenuispinum*, *M. Willemoesii*, *M. inflator*, *and M. Murrayi* are originally descended from androgynous forms, in which the organs of one sex have become gradually abortive, for in *M. cysticolum* the female possesses rudiments of testes, but no generative aperture. It is also possible to trace out, in various species, almost every step from typical hermaphrodite forms to others in whom only one or other set of organs is capable of detection, qualifying the individual as male or female as the case may be. There remains yet one fact in connection with this subject. In the case of the embryos of *Myzostomida cysticola* sexual development begins in both sexes with the appearance of the testes; but in the female the testes atrophy, or leave but a minute rudiment when the ovaries are visible.

We must now pass on to consider another extraordinary condition of the generative organs in an invertebrate form, which to my mind seems to be among the most remarkable examples of atrophy of one set of structures the result of hypertrophy of others to be found anywhere in the animal kingdom. It has an additional interest in that the main details were set forth in a clear light by one of the greatest masters in natural history. The animals in question are the Cirripedia, or barnacles. It would obviously be out of place to enter into details concerning the anatomical peculiarities of this remarkable group. To be brief, the matter runs thus:—The older anatomists regarded the barnacles as molluscs until Thompson, in 1830, discovered that they underwent a metamorphosis, and were in reality crustaceans. A correct notion as to the general appearance and organization of a cirriped may be gathered from the accompanying drawings (Figs. 38, 39). The larvæ leave the eggs as nauplii, and are of an oval or pear-shaped form with unpaired frontal eye, lateral frontal horns, and three pairs of appendages. After moulting several times the larva enters what is known as the cypris stage, in which it undergoes several remarkable changes, but still maintains a free existence. Eventually the cement gland begins to secrete cement, which hardens and brings about the permanent attachment of the young animal, and eventually it becomes transformed into a cirriped. Its condition is that, to use the words of Professor Huxley, of a crustacean, fixed by its head, and kicking the food into its mouth with the legs, for on watching these animals the only sign of life is the alternate protrusion and

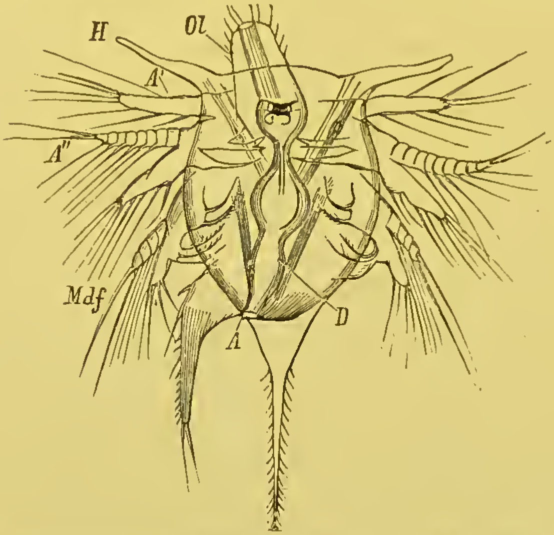

Fig. 38.—The Nauplius or Free Stage of a Cirriped. (After Claus.)

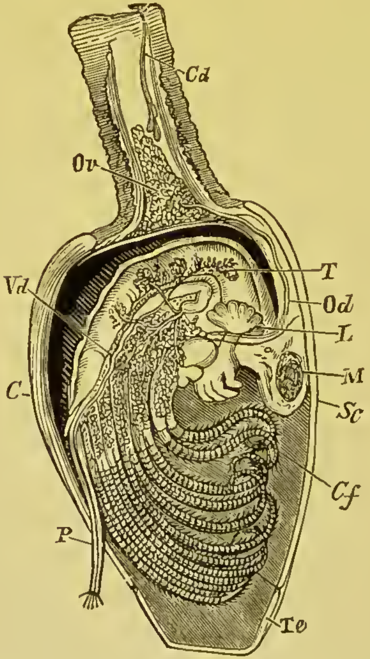

Fig. 39.—The Organization of a Barnacle. (After Claus.) Ov, ovary ; Od, oviduct; Vd, vas deferens ; P, penis ; T, testis; Cd, cement gland ; Cf, thoracic appendages.

retraction from the valvular opening of the animal's case, of a bundle of curved filamentous cirri, which sweep with a brushing motion through the water, and impel the floating nutritive matters towards the mouth.

These animals are commonly hermaphrodite; but Darwin, when dissecting the species known as *Scalpellum vulgare*, observed what appeared to be one or more very minute parasites on the margins of both scuta, close to the umbones. At first he thought he had to deal with some new class or order amongst the articulata, but repeated dissections and careful observations soon revealed to him that he had really before him a cirriped of the male sex. These males are very minute, often exceedingly minute, and consequently generally more than one is attached to a single female, and Darwin says he has seen as many as fourteen adhering to a single female. These males were termed by him complemental males. In several species the males are short lived, for they cannot feed, being destitute of a mouth and stomach; indeed, they are so rudimentary that they may be said to exist as mere bags of spermatozoa. Perhaps the most remarkable are the males of the species *Alcippe* and *Cryptophialus*. The females live in cavities which they excavate in the shells of molluscs, and within which they are attached by a horny disc; this disc is the only part of the outer integument which is not frequently moulted, and apparently in consequence, the males are attached to its edge. It results from this position that the males are protected by being enclosed within the cavity excavated by the female; and it further results that the males are attached at a considerable distance from the orifice of the sac of the female, into which the spermatozoa have to be conveyed; and to effect this the probosciformed penis is wonderfully developed, so that in *Cryptophialus*, when fully extended, it must equal between eight and nine times the length of the animal! (Fig. 40). These males, like those last mentioned of *Scalpellum*, consists of a mere bag lined by a few muscles, enclosing an eye and attached at the lower end by the pupal antennæ; it has an orifice at its upper end, and within it there lies coiled up, like a great worm, the probosciformed penis, and beneath it a single testis, with a single vesicula seminalis. These organs complete the whole organization of the male; there is no mouth, no stomach, no thorax, no abdomen, no appendages or limbs of any kind, yet all these parts are present in the female. I know of no other instance in the animal kingdom of such an amount of abortion (Darwin).*

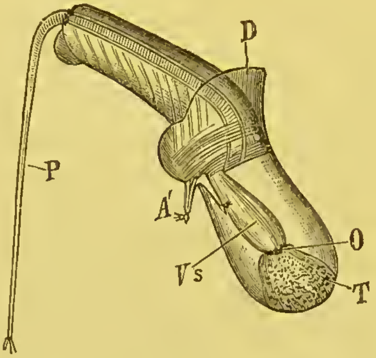

FIG. 40.—A COMPLEMENTAL MALE OF A CIRRIPEDIA (CRYPTOPHIALUS). (After Darwin.)

P, penis ; Vs, seminal vesicle ; T, testis.

Anyone who has followed this account will readily perceive that these complemental males illustrate the following facts:—

Hypertrophy of the male generative organs has led to abortion of the greater part of the animal, the abortion being also in part due to the protection afforded by the female; and the existence of these complemental males spares the cirripedia the risks likely to result in their fixed condition from the evil effects of continual self-fertilization.

The above account of the remarkably specialized males seems so strange, that anyone may be tempted to feel sceptical on the matter; but Darwin enters into so masterly a discussion of the evidence, that his theory has been generally accepted. Indeed the latest researches on this subject, those of Professor Hoek on the *Challenger* cirripedia, go to substantiate the truth of Darwin's views with regard to the occurrence and structure of these complemental males.

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* "A Monograph on the Cirripedia," Ray Society, 1854.

Chondrocanthus gibbosus is a somewhat similar case; but we cannot do more than mention it in this connection.

Among mammals, the most striking example of the peculiar value of hypertrophy must be noticed the curious malformed generative organs which occur in the cattle known as "Free-martins." Hunter was one of the first to carefully investigate the condition of the reproductive organs in these cases; and the valuable dissections he made, now in the Hunterian Museum, are monuments of his inquisitiveness in this matter.

Stock-breeders hold the opinion that when a cow produces twins, one a male and the other a female, the latter is unproductive (imperfect). This is very frequently true; but by no means always so. An imperfect calf under these conditions is known as a Free-martin or Martin-heifer. Careful comparison of the detailed descriptions of the dissections of these malformations, and similar cases in sheep and goats which have come under my observation, show most conclusively that in these cases we have to deal, not with any one malformation common to all examples of Free-martins, but rather with instances in which both sets of organs have attempted to attain a functional condition, with the result that both have failed to reach it. In some of these cases the Wolffian ducts have advanced many stages towards making a fairly complete set of efferent ducts for the testicles, and the calf approaches somewhat to a bull-calf. In other instances the Müllerian ducts have made greatest progress, and a diminutive uterus can be made out, and in this case the calf most resembles a cow-calf. Between these two extremes there is every gradation and variation. Similar cases occur in fishes, reptiles, amphibians, birds, etc. I have seen many cases, and numberless instances have been recorded out of curiosity.

In regard to cows, it is very easy to see why the malformations mentioned should be so frequent in them, for

Gartner's ducts, the representatives in the female of the vasa deferentia in the male, are persistent throughout life as considerable-sized tubes. The shape of the uterus when cleanly dissected is of the most primitive kind, and on looking at the parts as shown in Fig. 41, it need not surprise anyone that such an arrangement of parts, so little in advance of the embryological condition of these organs, should be so liable to produce the condition known as the Free-martin.

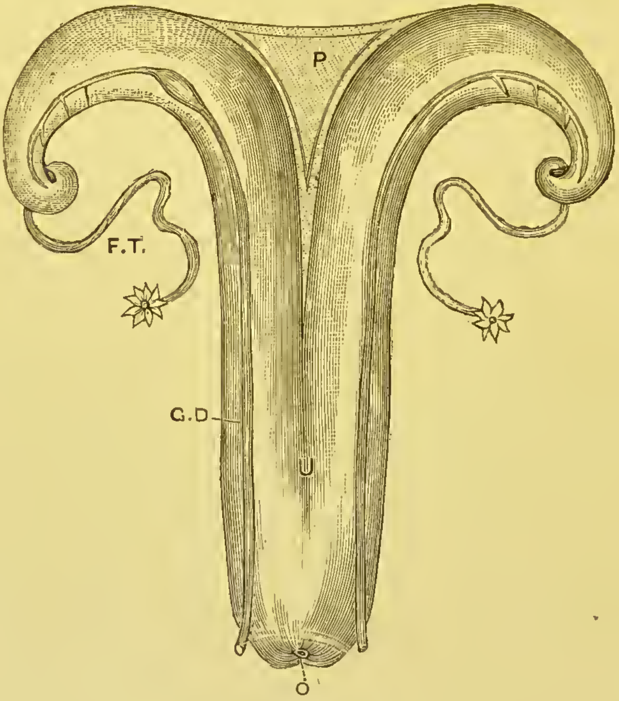

Fig. 41.—Uterus of Cow.
F T, Fallopian tube ; G D, Gartner's duct ; U, uterus ; O, os uteri ; P, peritoneum.

Various malformations show most conclusively how impossible it is for both sets of reproductive organs to attain a functional condition in the same individual. Hypertrophy of one set must arise and establish pre-eminence over the other.

The facts on which the argument rests, that hypertrophy is one of the causes of division of sexes, may be summarized as follows :—

(1) In the lowest forms of animal life, hermaphroditism is the prevailing condition.

(2) Cross-fertilization in hermaphrodites is the rule, and may, as in some of the *Myzostomida*, lead to a division into sexes within the limits of a single group.

(3) Sporadic cases of hermaphroditism are far more common in the lowest forms of life.

(4) If in mammals both sets of organs grow concurrently, the individual is sterile.

(5) Both sets of organs grow equally to a definite period in embryonic life.

(6) Reproduction in vertebrata, so far as is known, is impossible unless hypertrophy of one set of organs occurs.

The most remarkable instance of the correlation between hypertrophy and atrophy is that of the allantois. All members of the great group Ichthyopsida (fish and amphibia) are characterized as follows:—During some period of their life they breathe by means of gills, they never develop an amnion, and the allantois is always rudimentary. There is no form known in which gills and a functional allantois co-exist. Balfour pointed out that the allantois is to be regarded as a hypertrophied urinary bladder, which, being very vascular, carries on the work of embryonic respiration. Great care has been taken in the early part of this chapter to show that, when one organ becomes hypertrophied, others atrophy, and it is obvious to me that the assumption of the work of embryonic respiration by a hypertrophied bladder, under the name of allantois, abrogated the function of the gills and brought about their atrophy. Later in the process of evolution, the placenta began to replace the allantois, until in the higher mammalia its importance, as compared with its reptilian and avian development, became more or less secondary. That the loss of the gills is dependent on the allantois and not on the advent of lungs, is shown by the fact that lungs and functional gills co-exist throughout life in such forms as Lepidosiren, Ceratodus, and for a time in very many amphibians.

These speculations are very interesting, inasmuch as they show that the same process whereby a single kidney may carry on the work of its diseased companion, is only an example of a valuable process which has wrought profound modifications in the whole animal kingdom.

It is to be hoped that the examples of what should be considered hypertrophy, as compared with simple overgrowth, have been sufficiently convincing to impress upon my readers the importance of the distinction. Viewed in this light, hypertrophy shows itself as a process of extreme beauty, utility, and interest, especially when we reflect that the same process which enables one kidney to recompense the organism for the loss of its fellow, is only an instance of the method by which the tibia has outgrown the fibula; the disappearance of gills in all forms of vertebrata above Ichthyopsida has been brought about by the allantois, the division of reproductive labour and the institution of sexes, and many other equally important results which will be incidentally referred to in other parts of these Lectures, are the outcome of the indisputable correlation which exists between hypertrophy and atrophy.

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CHAPTER V.

DEGENERATION.

The term degeneration is used in pathology to include a class of morbid processes which affect the tissues of the body by altering their quality, impairing their function, and often leading to annihilation of their histological elements.

Thus if a muscle be put out of use by division of its dominant nerve, the essential contractile substance of the muscle-fibre becomes converted into fat. To such an alteration of texture as this it is convenient to apply the term degeneration.

Degeneration differs from atrophy in that it is a difference of quality, whereas true atrophy is a quantitative alteration in the tissues composing an organ; nevertheless degeneration of the elements of an organ often, indeed in most cases, precedes its atrophy. So intimately associated are the two processes that it is difficult at times to dissociate the one from the other.

A viscus whose essential elements have undergone degeneration need not necessarily be diminished in size; very often the reverse obtains, and the size may be doubled and trebled.

The causes of degeneration, or degradation, of tissues are various, and will more appropriately be considered under the sections devoted to the discussion of each form.

Degenerations are conveniently divided into two groups—*Metamorphosis* and *Infiltration*.

(1) *Metamorphosis.*—In this form the protoplasm of the cell

undergoes conversion into a new material. For example, the glandular cells of the mammary gland, at the time of lactation, become converted into fat globules found in the milk; this is a physiological metamorphosis, but if the protoplasm of a nerve-cell change into fat, this is pathological metamorphosis. The changes usually included under this head are the fatty, cloudy swelling, mucoid and colloid. Some pathologists also include amyloid change.

(2) *Infiltration.*—This differs from the above inasmuch as the new material detected in the tissues is not derived from the protoplasm of the cells composing the affected organ, but is deposited in the intercellular tissue from the blood, which, like a stream, deposits its coarser particles, brought from various sources, where the current is slowest, so that we have to deal with an infiltration in the meshwork of the tissue. This is rarely followed by destruction of histological elements; hence the essential structure of a tissue is far less altered, and function less interfered with, than in the serious changes which accompany metamorphosis.

For example, in the skeletons of the cartilaginous fishes, the hyaline matrix is extensively impregnated with salts of lime; this is a physiological infiltration, but to find large tracts of the tunica intima of an artery, or the muscle-fibre of the heart, thus infiltrated, is pathological, and often a serious source of danger to the animal.

The infiltrations are three in number, and include fatty, calcareous, and pigmentary infiltrations. Under certain circumstances, metamorphosis and infiltration may occur together in the same organ and tissue.

Fatty Degeneration (Metamorphosis and Infiltration).—It seems to be the duty of certain tissues in particular regions of the body to store up fat in their cells, whether the fat be derived from without or formed in the cell on the spot. Thus the subcutaneous tissue in most animals contains a large quantity of fat, which reaches its maximum in the Greenland right whale, constituting the well-known blubber. The hare has no such layer of fat near the skin, and in the bird *Bucorvus Abyssinicus*, adipose tissue is likewise absent; between these two extremes all degrees are met with. The omentum, mesentery, orbital areolar tissue, and white marrow of bones normally contain a large quantity of fat. Increase in the quantity of this surplus fat may depend on increased supply of nutritious material, or on diminished expenditure. This condition is known as *lipomatosis*, and ought not strictly to be considered as a degeneration. Seeing that it is the legitimate function of some cells to store up fat in their interior, as in the case of the connective-tissue cells, and in a certain degree the liver cells, it is exceedingly difficult to draw the line between the physiological and pathological production of that substance. In those cases where the albumen changes into fat, and the lost albumen is not replaced, the production of fat is necessarily associated with atrophy of the protoplasm, and impairment of function results.

The cells of organic fluids, such as pus, often undergo fatty degeneration. This process may be observed in inflammatory products, *e.g.*, the exudations characteristic of pneumonia, and the cells found in degenerate patches in cases of cerebral softening.

The appearance presented by a cell undergoing fatty degeneration is very characteristic. The oil-drops in its interior are colourless, but bright, with dark contours, insoluble in acetic acid, but soluble in ether and alcohol. If the parts be treated with perosmic acid, they stain black. The number of oil-globules in any individual cell vary greatly, and though individual drops may fuse to form one globule, they are never at any time of considerable size.

If large tracts of tissue undergo fatty degeneration, *e.g.*, the liver, the change is obvious to the naked eye. If a part be affected to any marked extent, it is at first usually increased in volume. Later the degenerate tissue may lose water, suffer condensation, and even caseate.

Among other substances found in degenerate tissues must be mentioned cholesterine.

Causes.—Fatty degeneration is not the result of any one cause, but of several. Probably the chief cause is deficient oxidation; at any rate, it is the most important one. If the food contain an excess of fat, or of substances capable of being converted into fat, the oxygen taken into the body fails to oxidize the excess, and accumulation in the cells results. If increased storage continues, the fat will not only accumulate in normal situations, but in tissues where it is not usually found.

On the other hand, the storage of fat is only normal in quantity, but oxidation is diminished or imperfectly performed, undue accumulation is the result. This is well seen in the livers of wild animals in captivity; they are well fed, but get little exercise; hence storage is at a maximum, oxidation at its minimum. So potent is this in causing fatty liver, that these imprisoned animals nearly always present this condition.

Fatty degeneration takes place in conditions associated with general or local anæmia; this probably comes about on account of diminished oxidizing power on the part of the blood, whereby its nutritive value is considerably reduced.

If from any cause a particular organ receive too little blood, either from obstruction to the nutrient artery from without, or disease within its walls, the organ or part affected is apt to suffer fatty change; this is well seen in cases where a cerebral artery is plugged by an embolus, or the cerebral circulation interfered with by ligature of one of the carotid arteries.

Organs which are not exercised fail to get as good a supply of nutrient fluid as those in constant or frequent use, and their constituent parts degenerate in consequence. This is exemplified in limbs put out of use by paralysis. Even the bones suffer extreme atrophy in old-standing cases.

It is clearly recognized that hybrid animals are often sterile; this sterility depends very frequently on malformation of the reproductive organs, and often on fatty degeneration of the ovaries. This is extremely well shown in the case of salmon.

In the "Sitzun. der K. Ak. der Wis.," lxxii., p. 235 (1876), Fitzinger records some experiments in connection with the hybridization of salmon. The crosses were made with the charr (*S. salvelinus*), the lake trout (*Trutta lacustris*), and the sea trout (*Trutta fario*).

In these experiments the hybrids were sterile, the sterility depending on degeneration of the ovaries and testicles. Fitzinger found these organs recognizable only in young individuals, and the eggs in the oviducts scarcely exceeded millet seeds. In the older fish the generative organs were transformed into fat. Fatty degeneration of the ovaries has been observed in many sterile hybrid mammals.

There seems to be, as Otto[*] was the first to demonstrate, some intimate relation between absence of nerves and fatty degeneration; and he points out that parasitic fœtuses, which, as a rule, are devoid of nerves, always contain a very large quantity of fat in lieu of more important tissues—muscles and the like.

By way of illustration, the following example will be quoted:—A woman in the fifth month of gestation fell downstairs upon her abdomen. At the eighth month she was delivered of a child, the upper part of the body presenting the proportions of a fœtus of corresponding date, but all parts below the navel agreed with those of an embryo at the fifth month of intra-uterine life. Dissection showed that the spinal column ended at the first lumbar vertebra, the remaining lumbar, sacral, and coccygeal elements being absent. The skin of the legs was exceedingly thin, and, on reflecting it, the bones were found to be thin, and to present the characters of those of an embryo at the fifth month. All the other tissues of the legs, muscles, nerves, ligaments, etc., were represented by adipose tissue.

In this instance it is probable that when the mother fell, she fractured the spine of the fœtus; the result was to cut off nervous influence from the legs, which in consequence retrograded into fat. For other examples of this relation of fatty degeneration to loss of nerve influence, see "Med. Chir. Soc. Trans.," vol. lxviii., p. 293.

The Later Effects of Fatty Degeneration.—When atrophy and degeneration affect such structures as muscles and nerves, or even bone and cartilage, the ultimate effect is, providing the organ is not absolutely essential to the life of the animal, to reduce them to the condition of fibrous tissue. For example, if the nerve supplying a muscle be cut or otherwise destroyed, the muscle belonging to that nerve undergoes fatty degeneration, and its active contractile protoplasm eventually disappears; all that remains may be simply a band of fibrous tissue, enclosing, perhaps, fat cells here and there. In the case of muscles, the greater portion of the fibrous tissue represents the peri- and endo-mysium of the original muscle. Not only is functional muscular tissue liable to this change, but such tissue, when developed in tumours, either as teratomata or leiomyomata, is exceedingly prone to this degenerative change, as will be shown when dealing with these growths. Bone and cartilage are often represented in this humble fashion; for example, the Meckelian and the stylo-hyoid ligaments are the remains of familiar structures; even the fibula is at times so represented. Arterial tissue likewise becomes converted into fibrous tissue, *e.g.*, ductus arteriosus, ductus venosus, hypogastric arteries, and umbilical vein; many other instances could be quoted.

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[*] "Compendium of Human and Comp. Path. Anat." (South's Translation, 1831).

It is exceedingly difficult to form any adequate conception of the extent to which this process has been operative in producing many accessory structures in the bodies of animals. Many of the ligaments of joints have had their origin in this way.

Cloudy Swelling.—The term "cloudy swelling" is applied to those alterations in the tissues which occur in the course of certain diseases which are accompanied by marked and continuous elevation of temperature. The change is especially seen in the liver, heart, kidneys, and muscles of those who die from the acute specific fevers, such as typhus, typhoid, etc., acute rheumatism, and pyæmia.

The microscope shows that the process consists in the formation of free granules in the substance of the affected cells. These granules are soluble in acetic acid, and insoluble in alkalies and ether; they may be regarded as albuminoid bodies. Their presence in the cell gives it a cloudy appearance, its normal form and structure being lost. If this degeneration only advance to a certain stage, it may be recovered from, and function restored. In severe cases the cell-substance is metamorphosed beyond recovery, and perishes. The supervention of such a change as this in the course of an acute disease must seriously interfere with the function of such an important organ as the heart, and constitute a serious element of danger. Probably its chief cause is deficient supply of oxygen, due to the abnormal condition of the blood in acute diseases, and it may be regarded as one of the earliest stages of the metamorphosis of the protoplasm of the cells into fat.

Mucoid and Colloid Degeneration.—Mucoid degeneration consists in the metamorphosis of the albuminoid constituents of the tissues into *mucin*; as the result of this they become soft and gelatinous. This form of degeneration of the tissues has its physiological type in the secretion of mucous glands.

The human submaxillary gland contains great numbers of cells distinguished as mucous, which have certain peculiar characters. When the gland is inactive the mucous cells are large, clear, and almost spheroidal in shape, and readily distinguished from the serous cells. The peculiar appearance of these cells is due to the accumulation within them of mucin or mucin-forming substance. When the mucous glands are stimulated to secretion the mucin cells become smaller and gradually less clear, and their contents are extruded in the form of mucin, which is to be regarded as the result of cell-disintegration.

Mucus may be described as a viscid transparent fluid allied to albumen; it swells up readily on the addition of water, coagulates on the addition of acetic acid, becomes white, opaque, and turbid on the addition of alcohol; it is soluble in free alkalies.

The connective tissues of the fœtus consist almost entirely of soft mucin-yielding substance; also the umbilical cord, vitreous humour of the eye, and the exudation from mucous membranes, particularly in the early stages of catarrhal inflammation.

The mucoid change occurs in sarcomatous growths, in myxomatous tumours, in cartilages, and mucus-yielding fluid is often found in the interior of cystic formations.

When mucoid change occurs in a part, softening results in the affected tissue, which becomes transformed into a homogeneous, colourless material, of a soft jelly-like consistence. If the change be limited to isolated spots, a cystic condition is simulated.

Mucous degeneration plays an interesting part in the economy of many animals; indeed, some are mainly dependent upon it for obtaining their food. This is well shown in the case of the anteaters, especially the great anteater, *Myrmecophaga jubata.* In this animal the submaxillary gland attains enormous proportions, measuring in length sixteen inches, and in width two inches, whilst the adhesive property of the mucus secreted by the gland in this singular animal is equal to that of gum, thus enabling it to secure the ants on which it feeds.

The slime so characteristic of most fish results from mucous changes of its epidermis. The highest use of this form of degeneration is in supplying poisonous snakes with their deadly secretion. Nature makes subtile use of this particular process when she provides articulations in the limbs of vertebrate animals. If we examine the limb of a chick at a very early stage, we shall find that the limb has an axis composed of a single undifferentiated rod of cartilage or prochondral tissue. Subsequently the tissue, at spots corresponding to the future joints, undergoes mucoid changes, ending in complete solution of continuity of the original rod of tissue. This may be observed not only in the case of such joints as the knee, hip, ankle, etc., but even in the case of the joints between the carpal and tarsal bones. It is due to this change also that the joints are supplied with the glairy lubricating fluid known as synovia.

This fact is of some interest, in that it serves to explain why so many of the connective-tissue tumours, especially sarcomata and enchondromata, are so prone to undergo the mucoid change.

Colloid degeneration is closely allied to the preceding variety, but differs from it in the fact that the cells are more affected in the colloid than in the mucoid form. The colloid material closely resembles mucin, but is not precipitated by acetic acid; alcohol and chromic acid produce no turbidity. It is a colourless, transparent, glistening substance of the consistence of jelly. Examined microscopically, it is homogeneous, has no cell-elements except at the margins of the mass where the change is advancing. When a number of cells have undergone the colloid change, they fuse together; in this way continuous tracts of degenerate tissue may be formed by the coalescence of smaller ones. Colloid change occurs in the thyroid gland of old persons, and occasionally in the young, so as to become pathological, a certain amount of colloid material in the alveoli of that body being physiological. It occurs also in the cysts found in the choroid plexuses of the brain, in cancers, and in cysts occurring in the kidney, due to colloid changes in the glomeruli in case of interstitial nephritis.

Infiltration of the Tissue with Salts.—Calcification, or calcareous degeneration, is characterized by the deposition in the tissues of various salts of lime. Physiologically it is a highly important process, and when it occurs in unusual situations, becomes pathological; but the mode by which the deposition occurs under the two conditions is precisely the same. In fish, *e.g.*, sharks and rays, whose skeleton is composed of cartilage only, deposition of calcareous particles takes place very largely, and adds to the strength of the framework. So, too, in the early stages of the formation of bone, the first step is the impregnation of the cartilage with salts of lime; careful microscopic examination shows that the granules are not only deposited in the matrix, but in the cartilage-cells. The forms of the calcific granules are irregular, and look like little grains of dust. If a calcified cartilage be dried, it assumes a characteristic white appearance. Calcification is essentially a passive process, and is most prone to occur in tissues which, like cartilage, have a small vascular supply. Permanent chondrified tracts in all parts of the body have a great tendency to lodge mineral salts, *e.g.*, the costal, cricoid, thyroid, and tracheal cartilages, as life advances, and abnormal tracts of chondrified tissues, such as occur in certain tumours, the enchondromata and chondrifying sarcomata.

Calcification is exceedingly prone to attack tissues whose nutrition is interfered with, or which are in an actual state of necrosis, such as caseous patches, the result of inflammation, or the subsequent shrivelling up of parts which have undergone fatty degeneration, encysted parasites, *trichina spiralis*, dried hydatid cysts and the like, thrombi, and old hæmorrhagic patches. Fœtuses sometimes undergo a process of calcification known as lithopædia.

In many of these cases calcification is of little importance, but when occurring in arteries and cardiac valves it is otherwise. In these structures calcification may be either a primary or a secondary affection. As a secondary process it is one of the terminations of the atheromatous process, being exceedingly frequent in the aorta in man and horses. Primary calcification is less frequent, and is one of the changes incident to old age. It is most common in the medium-sized arteries of the limbs and brain. In these situations the cells, as well as the intercellular substances, become calcified. The process does not produce any alteration in the structure, but the tissue becomes calcified without destruction or transformation of its form and texture. In this respect calcification differs from fatty degeneration. Under these conditions the vessel loses its elasticity and contractility, its lumen is narrowed, and it becomes transformed into a hard, brittle tube. If the saline matter be dissolved out with dilute mineral acid, the structure of the artery may be again recognized.

The calcareous matter deposited consists for the most part of lime and magnesian salts, especially phosphates and carbonates.

Certain parts of the brain are liable to this change, *e.g.*, the pineal gland and the fringes of the choroid plexuses, and under certain circumstances the ganglion cells of the brain have been found calcified.

It has been already mentioned that primary calcification, that is, without any antecedent disease, is not of common occurrence except in cartilage and in the walls of arteries. This makes the following remarkable case worth referring to:—

"The Veterinarian," 1851, contains an account of a calcified testis of a ram, reported by John Gamgee. The testicle weighed 14½ ozs., and in size and shape resembled its ordinary condition. The cut surface of the organ presented very small, yellowish-white, crescent-shaped objects, closely packed together, and in certain points seemed to be agglutinated by calcareous deposit. A careful examination showed that these minute objects were the seminiferous tubes impregnated with calcareous matter. In spite of this calcified condition of the tubules, the characteristic appearance of the testicle was so little altered, that when the specimen was shown to a distinguished anatomist, without any intimation as to its history, he at once suspected its true nature. Dr. Carswell had a drawing of a testicle of a goat with a similar calcified condition of its tubules.

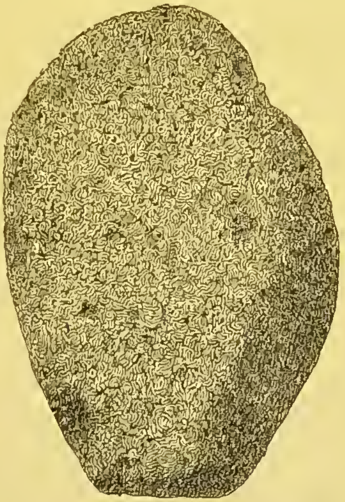

FIG. 42.—A CALCIFIED TESTIS FROM A RAM.
(After Gamgee.)

On comparing the specimen with Carswell's drawing and a calcified ram's testicle in the possession of the late Dr. Crisp, Gamgee came to the conclusion that the calcification commenced in the testicles independently of any change in their afferent and efferent vessels, because the epididymis and vas deferens were normal, and the deposition of calcific matter was primary in the tubules.

Besides carbonate and phosphate of lime, urates, chiefly urate of soda, are apt to form a constituent of these earthy deposits. This may happen in the cartilages of the ear and in the periarticular cartilages, and even in bones. Deposits of this character may occur in ligaments, in arteries, endocardium, skin, and kidneys.

These conditions arise in those people who present the gouty diathesis.

Pigmentary Changes.—Pigmentary degeneration consists in the abnormal formation of pigment in the tissues. Normally, many tissues contain pigment particles in certain regions of the body: thus, the rete mucosum of the skin contains a small amount, which reaches the maximum in the dark races of mankind. It may be well seen in the smooth portion of the tail of the prehensile-tailed monkeys. The choroid coat of the eye in nearly all mammals is another instance. The cuttle fish afford good physiological examples of the formation of pigment. In their singular ink-bags a black pigment is produced, which the animal can eject at will, in order to cover its escape from enemies, and in this way can render the surrounding water of an inky black colour for a square yard or more.

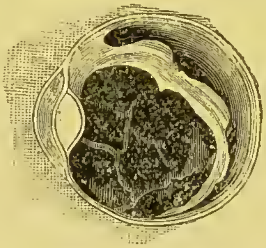

FIG. 43.—MELANOTIC SARCOMA OF CHOROID.

The highest degree of pathological pigmentation occurs in the new formations known as melanotic sarcomata, where the amount of pigment is so great in many cases that the fluid which exudes from them is of the colour of black ink. The pigment lies usually in the tissue-cells, sometimes in the intercellular substance, where it takes the form of yellow, brown, or black granules, or it may be diffuse in character, staining the protoplasm. In one rare form of cancer, chloroma, the colouring substance is green.

The liver is frequently pigmented; the explanation seems to be this: the hepatic tissue is traversed by a capacious and elaborate capillary system; the circulation is very slow, and this allows foreign substances suspended in the blood to become deposited. Pigmentation of the liver reaches its maximum in persons who have been long subject to ague. Pathological pigmentations may be arranged in classes according to the probable source of the pigment particles:—

(1) Hæmatogenous pigments are those derived from the colouring matter of the blood.

(2) Biliary pigments due to the presence of bile in the tissues when its excretion is hindered.

(3) Pigmentation from extraneous substances.

The fate of foreign particles when introduced into the blood has been made the subject of experimental research. When such substances as cinnabar and coal dust are introduced into the circulation, these substances are taken up by the leucocytes, which deposit them in the tissues outside the vessels. In many instances they are ingested by cells and conveyed along the lymphatics, and these "carrier" cells may be detected in the recesses of the lymphatic glands.

(1) *Hæmatogenous.*—Pigmentary changes rarely occur in circulating blood, but generally arise in blood which has escaped from the vessels. Extravasation of blood in the connective-tissue layers of the skin is at first brown, then blue, changing to green, and finally yellow.

If hæmorrhage occurs in internal organs, such as the serous membranes or lungs, it gives rise to brown patches, which later become grey, or even black. In the substance of the brain blood long remains of a brown colour, later becoming yellow. It is now known that these changes correspond to definite chemical and physical processes in the hæmoglobin of the effused blood.

When extravasation of blood occurs in the tissues, the subsequent changes may be summarized as follows :—

(*a*) A portion of the plasma and some of the red cells are taken up by the lymphatics and removed unchanged.

(*b*) The hæmoglobin from some of the remaining red corpuscles is set free by the disintegration of the cells, and diffusing itself through the plasma infiltrates the surrounding tissues, staining the cells and intercellular substance of a yellow or brownish-red colour. The yellow colouring matter is known as hæmatin, and as this substance passes through its various transformations, it gives rise to the change of colours previously mentioned.

(*c*) If the extravasation be large, some of the corpuscles shrink or crumble down into brown granular masses.

(*d*) The greater portion of the corpuscles and the products of their disintegration may be taken up by leucocytes, which are always found in considerable numbers around an extravasation, and even in its interior.

The ultimate result of a local extravasation of blood is pigmentation of the tissues in the immediate neighbourhood, and later, pigmentation of distant organs, such as lymphatic glands, liver, spleen, etc., due to the transportation of pigment granules by the lymphatics and leucocytes.

The more soluble substances which are taken up by the leucocytes, such as fat, myeline, and even necrosed bone, are more or less digested and assimilated by the attacking leucocytes ; only the insoluble pigmentary particles which resist the activity of these cells are deposited in the tissues.

(2) *Biliary Pigmentations.*—If from any cause the excretion of bile be interfered with, either from some impediment to its natural flow from the bile-channels into the intestine, or abnormal conditions of the hepatic gland itself hindering secretion, the biliary pigments pass into the general circulation, and are deposited in the various organs and tissues. The yellow appearance thus produced is known as jaundice, or icterus. If the coloration persist for any length of time it may become olive green. The colour is diffused

indefinitely through the tissues; granules and ruby-red crystals may sometimes be detected.

In the form of jaundice appearing within a few days of birth, and known as *icterus neonatorum*, these crystals may be found in the tissues in the form of ruby-red rhombic plates. They are composed of bilirubin, and are identical with hæmatoidin crystals. In jaundice occurring in adults the pigment is more granular, and in colour yellow or brown.

It must be borne in mind that the hæmatogenous forms of pigmentation are for the most part permanent, whereas the biliary colorations disappear if the impediment to the flow of bile be removed, or the normal function of the liver re-established. This has led some writers to speak of the biliary forms as false pigmentation.

(3) *Pigmentation from Extraneous Substances.*—It has been recognized from the most remote times that if any opaque substance distinguishable from the skin be incorporated with that tissue, it will remain unabsorbed, and give rise to a special coloration; hence savages have used this method to tattoo themselves—a custom not confined to them, but is resorted to by people who ought to consider themselves beyond such degraded practices.

The art of tattooing simply consists in puncturing the skin with a sharp needle, and then rubbing in insoluble granular matter, such as Indian ink, charcoal, cinnabar, etc. These tattoo markings tend to get fainter by age, on account of the lymphatics taking up the minute particles and depositing them in the nearest lymphatic gland. If the axillary lymphatic glands from a case of tattooing of long standing be examined, their outer layers will be found largely infiltrated with insoluble colouring matter.

Closely akin to this tattooing of the exterior of the body are the pigmented lungs of dwellers in large towns, due to constant inhalation of carbon particles, or the irritation of foreign substances in the inspired air, such as dust of coal, iron, rust, stone, and the like. In one form of miner's lung the tissue may become perfectly black.

Probably in no organ is pigment so frequently met with as in the lung. In young children the lungs are almost free from pigment; the amount increases with advancing years, by living in towns, frequent attacks of bronchitis, and dusty employment. Much discussion has arisen as to the origin of this pigment. There can be little doubt that a considerable proportion enters the air-passages during respiration, for in large towns there is always a great quantity of carbon particles in the air. These may be taken up by the cells and expectorated, but others pass into the air-vesicles, and gradually penetrate the pulmonary substance and lodge in the alveolar walls and interlobular connective tissue. Having gained this situation, and given the lungs a tattooed appearance, the lymphatics attempt the removal of the intruding particles, and convey them in considerable numbers to the bronchial lymphatic glands, where the pigment is often intensely black and as liquid as ink, so that it is possible at times to write with it.

The foreign particles are not alone responsible for the pigmentation, for their presence may excite inflammation, which leads to structural changes, accompanied by extravasation of blood. The changes this effused blood undergoes has been already referred to under hæmatogenous pigmentation.

The part played by extravasated blood in causing pigmented conditions of the lungs is well shown in that curious state of lung known as brown induration, where, on account of obstructive disease of the heart, the pulmonary capillaries become enormously engorged, and extravasation occurs, leading to a dark red or brownish colour of the interlobular tissue.

This is remarkably exhibited in the lungs of horses living in mines. Contrary to what might be expected, the lungs contain only a moderate amount of black pigment, but the alveolar walls are very thick and of a deep red colour, the capillaries being in places much dilated.

Fish are liable to a curious form of pigmentation as a result of irritation due to the presence of encysted parasites. This condition is probably most frequent in the carp family. Victor Fatio has given an account of this form of pigmentation as it occurs in the minnow, and the black patches on the body and fins. On carefully examining the pigmented area, a white spot can be detected in the centre, which is a small cyst containing the parasite *Displostomum cuticola* (Diesing).

A carp preserved in the museum of the Royal College of Surgeons is affected in this manner. The pigmented spots are very black. The specimen was originally considered to be an example of melanotic sarcoma; but careful examination led to the detection of a parasite in the centre of each pigmented spot.

Pigmentary degeneration may be studied in the liver of frogs and toads. This has been made the subject of careful observation by Eberth,* of Zurich, who points out that in a frog or toad in the winter, or in a captive frog which is hungry, the liver is loaded with pigment patches; this causes the organ to assume a much darker tint than is to be found in a frog caught in the summer.

Eberth also shows that the leucocytes play a very active part in this matter. On examining livers of frogs affected in this way, leucocytes may be detected with few pigment granules, whilst others are loaded with particles; and a third set contain so much black pigment that the nucleus of the cell is completely obscured. The source of this pigment is not obvious.

Amyloid Degeneration.—Amyloid degeneration is an important progressive degenerative process, characterized by the formation or deposition in the affected tissue of a peculiar albuminoid (amyloid) substance, which causes them to increase in bulk and have a uniform semi-translucent appearance. The presence of this substance diminishes the vitality of the affected tissues, and impairs their functions.

This degeneration may affect any organ, but it is especially common in the spleen, liver, kidneys, intestines, and lymphatic glands.

When well pronounced, the morbid change may be recognized with the naked eye, the parts presenting a semi-translucent look, like the fat of bacon; hence the term "lardaceous" sometimes applied to it. The affected organs increase in size, and are firm and hard to the touch. These changes are best observed in the liver. In the spleen the amyloid substance may be infiltrated throughout the substance of that organ, but frequently it is deposited in scattered patches resembling grains of boiled sago or tapioca; hence the term "sago-spleen." The changes in the kidney are not so obvious, the amyloid material often being masked by fatty changes in the surrounding renal tissue. In the intestine the changes are rarely to be detected without the aid of the microscope or the application of chemical tests. This also applies to the heart, thyroid gland, suprarenal capsules, etc., organs which are less liable to the change.

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* "Virchow's Archiv," Bd. xl., Hft. 3.

The causes of amyloid degeneration are little known, although the circumstances under which it is apt to occur have been recognized for a long time. The constitutional conditions which lead to well-marked amyloid changes are syphilis, tuberculosis, chronic ostitis, and periostitis, chronic dysentery, leukæmia, and those diseases which are attended by long-continued and profuse suppuration, such as empyæmia, pyelitis, and the like.

Amyloid degeneration may, however, be primary—that is, occurring independently of previous disease. This change is very rarely seen in animals, and the reported cases were met with in horses. This is of some interest, for profuse and long-continued suppuration is exceedingly rare in animals, although such an event is occasionally seen in horses.

CHAPTER VI.

NUTRITION ARRESTED—NECROSIS.

It is the chief function of the blood to act as means of communication between the various tissues of the body; they are in reality dependent upon a constant supply of this fluid in order to maintain their integrity. Any very serious and continued disturbance of the normal condition of the blood is incompatible with the continuance of life, hence death results. This is often termed *somatic* death, as contrasted with *local* death, that is, death of an integral portion of the organism—a few tissues, a piece of skin, or even a limb; this somatic death is distinguished as *necrosis*, and may arise from a variety of causes.

Thus obstruction to the flow of the blood in a part, due to impediments in the arteries, capillaries, or veins, is often attended with serious results. Diminished action of the heart often produces the same effect. Inflammation, physical and chemical agencies are often the means of causing death of a part of the body, whilst the rest retains its vitality. As the effects vary according to the nature of the cause, it will be necessary to consider the matter somewhat in detail.

(1) *Obstruction to an Artery.*—This may arise from embolism, thrombosis, pressure, calcareous degeneration of its walls, or from a ligature designedly placed around the artery.

In necrosis from this cause the dead tissue becomes dry, the skin assumes a black, leathery, mummified condition, and is technically known as *dry gangrene.* In cases where the necrosis is brought about by calcification of the arterial walls, it is often distinguished as *senile gangrene.*

The mummification of the tissue is due to two factors, viz., no blood flows into the necrosed part, whilst constant evaporation is going on. The blackness and lividity of gangrenous limbs are due to the transudation of blood into the tissue. In cases of gangrene from frost-bite, the colour of the limb or part affected may be of a tallowy whiteness. In cases of dry gangrene, the tissues, when examined under the microscope, present a withered or shrunken appearance. The separation of the remains of the umbilical cord a few days after birth is a good example of this form of necrosis.

The time required to produce necrosis as a result of deprivation of the blood-supply varies in different tissues. Cohnheim considers that brain-tissue, renal epithelium, and intestinal epithelium die within two hours; skin, bone, and connective tissue may live twelve hours. As a rule, it may be stated that those tissues which exercise special functions—brain, retina, muscle, intestine, and the like—die much more quickly than the connective tissues, such as tendon, fibrous and cartilaginous tissues.

(2) *Obstruction to Veins.*—When the obstruction affects the veins, there is nothing to hinder the free entrance of blood into the limb; hence the tissues become engorged and bathed with blood and the fluids exuding therefrom. This is frequently distinguished as *moist gangrene*, which may be defined as, necrosis followed by decomposition and putrefaction of the affected tissues. The essential difference is that the dead portion contains liquids exuded from the blood and tissues; this forms a nidus for putrefactive organisms, which assist in the work of decomposition, and the part becomes quickly disintegrated. Various gases, such as sulphuretted hydrogen, ammonium sulphide, etc.; crystalline bodies, such as triple phosphates, tyrosin, leucin, etc.; pigment granules, brown

and black, make their appearance as a result of the decomposition of the tissues.

(3) *From Diminished Cardiac Power.*—Necrosis the result of diminished cardiac power is of interest. Very striking cases are seen in the later stages of constitutional diseases when adynamia becomes a marked feature. In a man dying from a severe attack of typhoid fever, the action of the heart became so feeble that his feet and the tip of his nose sloughed. On dissection no cause save that of failure of the heart's action could be discovered. From a similar cause I have known the tip of the tail in a monkey and a prehensile-tailed porcupine to slough.

Inefficient action of the heart may arise as part of a general weakness, but more often may be attributed to actual changes occurring in its walls or valves, *e.g.*, fibroid and fatty degenerations, cloudy swelling, and the like.

(4) *From the Effects of Ergot.*—It is well known that ergot, when admitted into the system, has the peculiar property of bringing about contraction of involuntary muscle-fibre. If excessive quantities be taken, contraction of the arteries supplying a limb is brought about, giving rise to gangrene. The records of French surgeons of the last century show that it was a well-recognized disease, but it is fortunately rarely seen in this country. Dr. Woolaston recorded in the "Philosophical Transactions," 1761, a most remarkable case, which occurred at Wattisham, in Suffolk, where a labourer, his wife, and family of six children were attacked with this form of gangrene.

The mother lost both feet; in the eldest daughters, girls of fifteen and thirteen, both legs became gangrenous below the knees; the next girl, aged ten, had lost a foot; a boy, aged eight, lost both legs below the knees; the next, aged four, lost both feet at the ankles; the infant died; the father lost two fingers.

Some writers seem to discredit many of the accounts given of cases of gangrene arising from the accidental introduction into the system of ergot; the following evidence will therefore be of interest:—

This disastrous effect of ergot is not confined to human beings, but occurs in cattle who have been so unfortunate as to eat ergotized grass. An admirable account of an outbreak of ergotism, which occurred at Kansas, in 1883, is given in the "Report of Investigations by the Department of Agriculture," Washington, 1883-84.

The most striking symptoms are stiffness of the lower joints of the limbs, coldness and insensibility of the affected parts. In severe cases a constricted band forms around the limb at the point separating the gangrenous from the living tissues, extending deeper and deeper into the tissues, until at last the limb is cast off.

Some animals lost only a toe; others would lose the foot at the fetlock joint; in other cases the disease would extend above the metacarpal bone (*vide* Fig. 44). In all cases the gangrene was of the dry variety, and not always confined to the limbs, for some animals lost a few inches of the tip of the tail, and in others the ears were affected.

(5) *From Thermal Causes.*—The extremes of temperature are powerful agents in destroying tissue-life. Thus it has been found that if the temperature be maintained at 54° C. to 58° C. for any time, the tissue is inevitably destroyed. Higher temperatures act still more rapidly. The lower limit within which life may be maintained is 16° C. to 18° C. (Ziegler).

When tissues are destroyed in consequence of the application of extreme heat, they are said to be *burnt;* if, through the application of liquids when hot, the term *scalded* is used. Necrosis from the application of extreme cold is known as *frost-bite.*

Some interesting experiments have been described by Mr. Coleman and Professor M'Kendrick* on the effects of low temperature on a rabbit and a frog.

The rabbit was placed in a cold chamber, the temperature of which stood at −93° Fahr. At the end of half an hour its temperature, taken in the rectum, was 94·2° Fahr., against the normal 99·2° Fahr. when introduced into the chamber. It was then exposed for an hour to a temperature of −100° Fahr. Reflex action was abolished; the temperature had fallen to 43° Fahr. When placed in a warm room it began to recover. When removed from the cold chamber, although reflex action was abolished, the muscles responded to electrical stimuli, and the sciatic nerve was still irritable. It would seem that the abolition of consciousness and reflex action were owing to the inactivity of the grey matter of the brain and spinal cord.

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* "Journal of Anatomy and Physiology," vol. xix., p. 343.

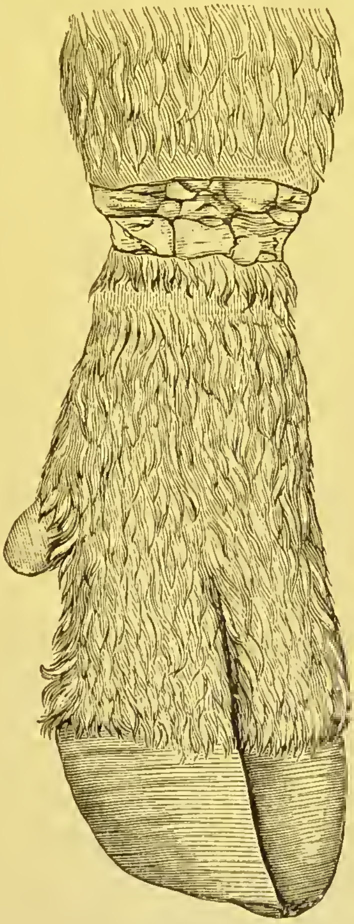

FIG. 44.—THE LEG OF A COW WHICH HAS MORTIFIED IN CONSEQUENCE OF EATING ERGOTIZED GRASS.

The line of demarcation is very evident.

These experimenters ascertained that a live frog may be frozen quite solid throughout by a temperature of from

−20° Fahr. to −30° Fahr., in about half an hour. On thawing slowly, in two instances the animals recovered completely.

When kept in the cold chamber longer than half an hour they did not recover, but the muscles and nerves responded to weak induction shocks. Reflex action was, however, abolished. Thus muscle and nerve can retain their irritability after being solidified by cold, even as low as −100° Fahr.

It is very striking that a frog exposed to a temperature of −100° Fahr., became as hard as a stone in from ten to twenty minutes, whereas the warm-blooded rabbit, exposed to the same temperature for an hour, developed enough heat to keep its body soft and comparatively warm during an hour's exposure.

The difference in effect in the case of the rabbit is really due to the skin of the animal, for I have known a *dead* monkey with its skin on resist being frozen when placed in a freezing mixture for three hours, when the flayed body of a young lion was frozen in the same mixture in one hour.

(6) *Necrosis from Chemical and Electrical Irritants.*—The application of various chemical substances, such as sulphuric, nitric, and hydrochloric acids, quickly destroys tissues.

Similar results follow the action of the caustic alkalies, *e.g.*, potassa fusa and strong liquor ammoniæ.

Among the physical forces, a strong electric current will immediately destroy life. This is seen in full force when men and animals are destroyed by lightning, or in accidentally coming into contact with the wires of the powerful batteries and machines now so largely used for generating electricity. In two instances where life has been destroyed in this way, the bodies were stated to have presented all the characters peculiar to men who have been killed by lightning.

Coagulative Necrosis.—This term was introduced by Cohnheim to describe a special form of local death. It occurs in two ways. When certain of the vital fluids, like the blood and lymph, escape from the vessels, homogeneous coagula form;

this constitutes one kind of coagulative necrosis. In the second form, cells and cellular structures, as they die, become firm and solid and coalesce into homogeneous masses.

The most familiar example is the coagulation of the blood when withdrawn from the body.

Under coagulative necrosis are included such conditions as waxy degeneration of muscle, or inflammatory exudations such as occur in diphtheria. The infiltration of Peyer's patches in typhoid fever, and the exudation in the alveoli during broncho-pneumonia, are regarded as of this nature.

Colliquative Necrosis.—This is used as the equivalent of the old term "softening." It would seem that this variety of necrosis bears somewhat the same relation to coagulative necrosis that moist bears to dry gangrene, except in the matter of micro-organisms. Colliquative necrosis is well exemplified in the condition known as softening of the brain. The constituents of the tissue break up and dissolve in the liquid which is poured out from the vessels.

Colliquation may affect coagulated tissues; thus thrombi which have formed in blood-vessels may soften. The exudations in cases of pneumonia often break down. It has been argued, and with some degree of plausibility, that this softening of coagula may in some instances be the result of organized ferments.

Having briefly considered the various forms and causes of necrosis, it is necessary to describe the steps by which nature enables the organism to rid itself of the dead parts.

When tissue dies, its presence is obnoxious to the living parts immediately surrounding it; indeed the sequestrum is to all intents and purposes a foreign body; the irritation causes inflammation, varying in intensity according to the amount of decomposition in the necrosed part.

This zone of inflammation is often very definite, and is known as the *line of demarcation.* The inflammation leads to thrombosis of the vessels, thus preventing hæmorrhage, and eventually the gangrenous parts drop off, and the surface heals over.

Among the deer tribe the annual shedding of the horns offers favourable opportunities for the study of necrosis, and the manner in which sequestra are cast off.

As every one knows, the antlers, when young and growing, are covered with a delicate vascular membrane known as the velvet, a membrane which bears the same relation to the growing bone of which the antler is composed, as periosteum bears to ordinary bone. As long as the horns retain this velvet in a living condition they increase in length and breadth; the animal takes every care of them, so as not unnecessarily to knock or bruise them, for I have ascertained that blows inflicted on the antlers of stags when "in velvet" are followed by nodes, much in the same way as blows on the shin. Such nodes may, on a large pair of antlers, attain the size of a small orange, and lead to their disfigurement if the deer be living in close confinement. Examined microscopically, old nodes present all the characters of sclerosed bone. In very recent cases plastic matter is thrown out exactly resembling that seen at the extreme end of a growing antler. The horn having attained full dimensions, it is difficult to maintain circulation through so thin a membrane; it in consequence shrivels and is shed. As a direct result of the shedding of the membrane, the bone composing the antler is thus deprived of its nourishment and suffers necrosis. This first affects the branches and extends thence to the beam, the extreme end being that first affected; but the interior of the bone long retains its vitality, due to the circulation in its interior, which is apparently not entirely dependent on the velvet. In this condition the stag's antler is a formidable weapon, its exterior being devoid of sensation.

The necrosis extends gradually to the pedicle, or that portion where the velvet and ordinary hairy integument meet. As the pedicle derives its nourishment from the ordinary integument, it escapes the necrotizing process, and a line of demarcation forms at the junction of pedicle and beam, eventually ending in the falling of the antler as a huge sequestrum. After the separation of the dead structure the surface of the pedicle is a typical example of a healing ulcer; its florid granulations, surrounded by a delicate bluish rim of cicatricial tissue, present a beautiful picture of this mode of healing.

That the fall of antlers is really due to necrosis, the result of defective nutrition, is strikingly illustrated in the muntjacs. In these forms the antlers are borne on pedicles as long as, and in some cases even longer than the horns themselves, and covered by the hairy integuments. As a consequence all those portions covered by the integument are never shed, but only those which are "velvet" covered.

SECTION II.

LEEDS & WEST-RIDING
[illegible]

CHAPTER VII.

INFLAMMATION.

This chapter will be devoted to the consideration of the inflammatory process, which may be defined as *the method by which an organism attempts to render inert, noxious elements introduced from without, or arising within it.*

Noxious elements capable of bringing about the phenomena peculiar to inflammation may be denominated *irritants;* some of them are very coarse, others are peculiarly subtile, often eluding detection. The causes of inflammation are so numerous and so important that a special chapter has been devoted to the consideration of irritants.

The objective symptoms of the inflammatory process—redness, swelling, heat, and pain—have been known since the time of Celsus. If an irritant such as a hot iron be applied lightly to the arm or any part where the skin is thin, so as not to destroy its vitality, we shall observe, in the course of a few minutes, that the part irritated becomes red, painful, swollen, and hot—in a word, it inflames. The redness and swelling, as Galen knew, are the result of increased afflux of blood to the part, and the exudation of serum; but the determining cause of the afflux of blood has exercised the ingenuity of pathologists to the utmost.

It remained for the genius of Cohnheim to devise experiments whereby the process could be objectively studied under the microscope.

Take a frog, which has been rendered insensible some hours previously by the destruction of its brain, and inject under the skin $\frac{1}{2000}$ of a grain of curare, or some chloral. After waiting one hour, open the abdominal cavity by a vertical incision about half an inch in length, and carefully draw forth a piece of the small intestine and spread it out evenly by means of cork, so that a portion of the mesentery may be conveniently arranged for examination under the microscope. Providing the operation be performed with care and skill, and is successful, the following facts may be verified :—The arteries are smaller than the veins, and the arterial stream is quicker than the venous. The passage of blood is rapid in the arterioles, and is accelerated with each beat of the heart. In the veins, the red corpuscles may be seen rushing along the mid-stream—the axial current—whilst the leucocytes cling to the sides of the vessel, this latter being a mechanical effect. This is the condition of health, and the frog's mesentery may remain in this state for hours, and many of the frogs die without manifesting any further phenomena. In successful cases, changes occur in consequence of the exposure.

(1) The current in the vein slows, and the leucocytes crowd the vascular wall; the currents in the capillaries participate in the retardation.

(2) A projection forms on the exterior of the vein, and if this be carefully watched, it will be seen to get thicker, increase in length and breadth, throws out processes, and at last becomes attached to the wall of the vessel by a narrow pedicle ; this yields, and a white corpuscle is now found outside the vein. If the field be scanned over, numerous corpuscles will be seen to have migrated also from the surrounding veins and capillaries, and in course of time a great multitude of leucocytes will be found outside the vessels, which quickly distribute themselves through the tissues in virtue of their amœboid movement. Associated with the escape of leucocytes is an exudation of liquid rich in albumen.

The above process has been observed not only in the frog's mesentery and the web of the foot, but in the tongue of the frog, the tails and fins of fish, the tail of the tadpole, and in the mesentery of mammalia. Any investigator possessing ordinary skill, and a fair amount of patience, may verify the above statements, and be convinced of the phenomena in question.

These experiments teach us that the *redness* of inflamed tissue, as seen in man, is due to excess of blood in the part; the *pain* felt is referable to pressure and tension acting on the sensory nerves distributed to the affected tissue; the *swelling* results from the exudation; and the increased *heat* of the inflamed surface is in the main to be attributed to increased circulation of blood through the part. These changes necessarily impair the function of the tissues; the accumulation of exuded matter and the interference with nutrition lead to subsequent changes. Thus the vascular disturbance is, in vertebrates, the most important feature in the inflammatory process. The great question is, What are the causes which originate all this vascular disturbance? For the present it must be simply said it is the result of irritation.

If we extend our observations to other animals, especially to the invertebrates, in whom many of the phenomena of cell-life may be studied with tolerable ease, we shall quickly become impressed with the important functions played by active motile cells.

So far as inflammation is concerned, there are three points to which it is necessary to devote especial attention; they are—

1. The capacity exhibited by certain cells of effecting a change of place and form.

2. The power of taking into their interior various substances with which they may come into contact.

3. The property they possess of decomposing organic material when in their interior or in contact with their protoplasm; this process is denoted by the term *intra-cellular digestion.*

The first of these—the inherent property possessed in many instances by protoplasm of moving with a rapidity perceptible with the aid of a microscope—is an acknowledged fact in Biology. It is also interesting to note that these protoplasmic movements may be induced or influenced by stimuli.

In its simplest form it was first studied by Rösel von Rosenhof (1755); what he described as a small "proteus," being in reality a large fresh-water amœba. Dujardin's observations on the shapeless contractile body-substance in many lowly organisms (Rhizopods, Infusoria, Polyps, etc.) were very important; then the discovery of movement in the cells of higher animals, such as the colourless blood-corpuscles (Wharton Jones and others, 1846); and later, the identity of animal and vegetable protoplasmic movement has been proved by a number of eminent observers. In 1863, Von Recklinghausen brought into general notice the wandering of amœboid cells in animal tissues—an event of very considerable importance in physiology and pathology. (For an interesting review of the "Physiology of Protoplasmic Movement," consult an article by Prof. Th. W. Engelmann.*)

This capacity of certain cells to change their shape and position is one of the commonest physiological experiments performed in the laboratory.

We must now consider the second question—the power possessed by certain cells of ingesting various substances presented to them.

In 1862, Haeckel showed that when *Tethys*, a naked (shell-less) mollusc, is injected with indigo, the granules are taken up by the blood corpuscles; and he further showed the occurrence of similar phenomena in the blood of various invertebrates.

One of the most important results of these observations was the discovery that the white cells of the blood of man and other vertebrata possess a similar property of taking into their interior solid particles of foreign matter, such as indigo or carmine, if it be offered to them in a finely divided condition.

Cohnheim made use of this property of the white cells in a very interesting experiment, by which he was able to satisfactorily demonstrate that the cells, which emigrate into the tissues of the cornea when inflamed, are derived from the blood-vessels. Having injected finely divided carmine into the circulation of a frog, then irritating the cornea, he had the satisfaction of finding that the emigrated leucocytes contained carmine granules which they had taken up from the blood-stream. The experiment was an important one, because it proved not only that the cells came from the blood-vessels—a point which needed little proof, as it can be directly observed—but that the cells present in inflammatory processes in non-vascular tissues, such as cornea, cartilage, and the like, are directly derived from the capillaries of the parts immediately adjacent.

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* Translated in "Quart. Journ. Micros. Science," vol. xxiv., p. 370.

Having considered the property possessed by the amœboid cells, of taking into their interior foreign bodies, it is now necessary to inquire into the ultimate fate of these ingested particles. This is a very important matter, and requires full consideration, for it is of the highest interest in connection with the process of inflammation and absorption.

It has long been known that when an amœba takes into its substance a green-coloured plant, and is kept under observation, we find that the ingested material gradually breaks up, loses its green colour, and finally disappears. The amœba is thus capable of taking in food, and of making it part of itself, a process conveniently named *nutrition*, this being the outcome of the process of digestion. When the process of digestion is carried on in a cell of this kind, it is spoken of as *intra-cellular*. This important process of intra-cellular digestion was at one time only known in the Protozoa or Porifera; but in 1875, Allman, in a memoir on *Myriothela*, suggested its occurrence in these forms. Then Metschnikoff, who has done more than any other observer in this most interesting line of inquiry, described the inception of solid food particles by the cells lining the alimentary canal of certain Planarians; and later he made similar observations on the Sponges.

Metschnikoff followed up his observations on the Sponges by some careful investigations on the subject of intra-cellular digestion, at Naples, where he made the following ingenious experiment:—

By using powdered carmine he was able to watch its penetration into the endoderm cells of many hydroid polyps and hydro-medusæ. In one case, that of *Mesostomum Ehrenbergii*, the turbellarian refused to take the carmine; so Metschnikoff fed a nais with carmine, and then induced *Mesostomum* to eat the nais. Examination showed the presence of carmine in the digestive cells of the turbellarian.

These curious researches attracted the attention of biologists in this country.

In 1880, Jeffrey Parker communicated to the Royal Society a paper, "On the Histology of Hydra *H. fusca*," which supports Metschnikoff's views. Parker's account of the process in hydra is interesting and to the point, therefore it will be considered in some detail.

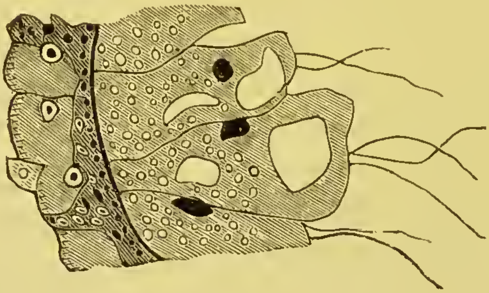

Fig. 45.—Transverse Section of a Hydra.

To show the large endodermic cells. (After Parker.)

Microscopic examination of the body of a hydra shows it to be a sac, the wall being composed of two membranes—an outer, known as the *ectoderm;* and an inner, the *endoderm.* Both are made up of nucleated cells. The inner ends of the ectodermic cells are prolonged into delicate fibres, which run parallel with the long axis of the body on the inner face of the ectoderm. In the endoderm and ectoderm the protoplasm of the cells contains the singular bodies known as the urticating capsules, or nematocysts, which are oval bags, with thick elastic walls, containing a spirally coiled-up filament, which is unrolled on the slightest pressure, and then presents the appearance of a long filament attached to the capsule, and is often provided with recurved spines near the base (Fig. 45.) Professor Huxley aptly compares the hydra to an aggregate of amœbæ, which are arranged in the form of a double-walled sac, and have undergone a certain amount of metamorphosis.

Parker, in the paper alluded to, whilst confirming the amœboid character of the cells of the endoderm in hydra, states that the extent and activity of these cells have not been sufficiently insisted on. In some cases, pseudopodia are given off to such an extent into the digestive cavity as to almost completely obliterate the latter. He also showed that they digest the material, for he found in the cells the partially disintegrated bodies of Entomostraca.

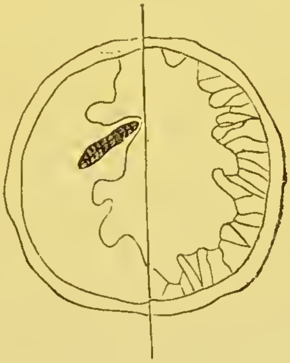

FIG. 46.—TRANSVERSE SECTION OF HYDRA.

To show the extent to which the endodermic cell can obliterate the digestive cavity. (After Howes.)

It is of the utmost importance to prove that digestion is carried on there. This question has been satisfactorily settled by Ray Lankester in the case of *Limnocodium.** In the summer of 1880 some fresh-water medusæ were discovered in the lily-house of the Botanical Gardens, Regent's Park, London. I can testify to the beauty and transparency of these forms, as I had an opportunity of examining several specimens. In these transparent medusæ, Lankester was able to establish the fact of the inception of *natural* food material by the endoderm cells.

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* "On the Intra-cellular Digestion and Endoderm of Limnocodium.' "Quart. Journ. Micros. Science," 1881, p. 119.

Interesting as these observations are, and valuable in proving intra-cellular digestion, yet an account must be given of the experiments by which Metschnikoff showed unquestionably that the *wandering* cells are capable of digesting organic substances.

If the fate of human blood-corpuscles be followed after their ingestion by the mesoderm cells of *Bipinnaria*, we shall find that they become completely absorbed. Within the cell they swell up and become clearer, the hæmoglobin is dissolved out, and finally the whole corpuscle disappears. Milk shares the same fate; the spherules are eaten by wandering cells, lose their shining appearance, and break up into small granules, which are distributed throughout the cell-substance.

Further, in order to show that the cells do not ingest everything indiscriminately, Metschnikoff experimented as follows:

The mucous tissue of a naked (shell-less) mollusc, *Phyllirhöe*, which is not only transparent, but large enough to admit of the performance upon it of simple operations, it is also hardy enough to survive for some time, was filled with a mixture of milk and indigo, carmine and starch granules—nutritious and useless bodies together; these bodies were absorbed, some cells eating the four kinds of food at one time. This would seem to show that they are *without* the power of distinction. However, on injecting into *Phyllirhöe* living ova from a sea-urchin, *Sphærechinus granularis*, it was found that neither young ovarian cells, nor ripe ova which had extruded polar globules, were eaten by the mesoderm cells; on the contrary, they seemed to live much longer in the tissues of *Phyllirhöe* than when placed simply in sea-water. Metschnikoff was also able to fertilize them whilst in the tissues of *Phyllirhöe*, segmentation and a normal blastopore being produced. If, however, boiled eggs of this animal be introduced, they are quickly fastened upon by the cells and devoured. Semen from *S. granularis* was also introduced; the spermatozoa were soon surrounded and eaten by the mesoderm cells.

Observations on the necrotic organs of several invertebrates, especially *Bipinnaria asterigera*, have shown it to be one function of mesoderm cells to devour the dying elements of such organs.

If fluids containing bacteria be injected beneath the skin of *Bipinnaria*, a sea-urchin, or *Phyllirhöe*, or if they develop spontaneously in the wounds of such animals, they will soon be found within the substance of many amœboid cells. Individual bacteria are often seen to retain their power of movement even after ingestion, whilst in other cases the motility is lost at once; and the whole bacterium is so delicate as to be scarcely visible.

In *Botryllus*, Metschnikoff has found a Spirochæta closely resembling the *S. Obermeyeri* of relapsing fever, and a small bacillus like the *Lepra bacillus*. Both these cells were pursued by the wandering cells, ingested and absorbed by them in various stages of development. Some of the mesoderm cells perished in the attempt, and were to all appearance dead, with long bacterial filaments projecting from them.

I have seen bacteria in the interior of the mesoderm cells of a Planarian: some of the bacteria exhibited the most lively movement; others were quite motionless.

The same thing holds good for vertebrates. Koch found the *Bacillus anthracis* and the bacillus of septicæmia in the mouse, enclosed by white blood-cells. Throughout the whole animal kingdom, mesoderm cells use their ingestive power for destroying bacteria and similar organisms.

Later, Metschnikoff has given to the world the result of some patient and valuable studies which go to establish the fact of intra-cellular digestion in other than the lower invertebrates. He did not limit his researches merely to those cells which act for the nutrition of the animal, but showed that this property is utilized for the removal of larval organs and the protection of the organism from irritant and harmful bodies. Before proceeding to give a brief *résumé* of this matter, it will be necessary to consider the embryological agreement which exists between the cells of invertebrata and vertebrata in whom this process has been satisfactorily detected, and explain two terms—"wandering cells of the mesoderm," and "plasmodium."

In dealing with the formation of the embryonic layers, it is important to remember that the epiblast and hypoblast are to be considered as the primitive layers, and that the mesoblast probably originated primarily as a differentiation from them. At any rate, this much is certain, that the mesoblast only exists in a fully developed condition in the forms more highly organized than the Cœlenterata.

In this layer arise the general connective tissues, internal skeleton, muscular, vascular, and excretory systems.

In almost all invertebrates the blood corpuscles are represented by cells, which may vary in number and in size, as well as being amœboid in character.

Whether we examine the blood of a star-fish, Amphioxus, squirrel, or a man, we shall find these colourless corpuscles present; and their appearance, properties, and mode of origin in these diverse forms are in complete harmony. Wherever the term "wandering cells of the mesoderm" is used, it signifies the so-called amœboid connective-tissue cells as well as the lymph and blood-cells.

Amœboid cells exhibit a very curious habit of throwing out pseudopodia, which unite with similar protrusions from neighbouring amœboid cells until a considerable mass of protoplasm is formed by their confluence. Such a mass of fused cells is known as a *plasmodium.* They have been particularly studied by Geddes* in the fluids of several invertebrates.

Metschnikoff has watched their formation in the transparent mollusc, *Phyllirhöe*, around masses of carmine granules. He writes:—"The cells came one by one to each lump, and flattened themselves upon it, fusing with neighbouring cells as these arrived. In this way arose plasmodia of very different sizes, some even visible to the naked eye, which may be compared to the giant-cells so often described in vertebrates." He also states that "in all cases in which I have found giant-cells (plasmodia) in invertebrates, they have arisen round foreign bodies, and always by fusion of separate cells." This observer has seldom noticed the formation of plasmodia in the blood of amphibia; but Geddes, in a footnote to his paper already referred to, states that Ziegler* has concluded, from his researches on the formation of giant-cells in exudation liquids, that a coalescence of amœboid cells does sometimes take place.

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* "On the Coalescence of Amœboid Cells into Plasmodia."—"Proc. Royal Soc.," 1880, March.

There is abundant good reason to believe that giant-cells in the higher vertebrata, when present, arise from the fusion of white blood-cells, and it will be convenient to refer to them, when they occur under pathological conditions, by Metschnikoff's very convenient term of *plasmodium*.

We must now consider some further examples of intracellular digestion.

Metschnikoff has pointed out that in the early stages of the absorption of the tails of larval batrachians a large number of amœboid cells are present, within which are remnants of nerve-fibres and fragments of muscle. These amœboid cells may be seen by simply teasing a piece of a tadpole's tail in which atrophy has commenced, in serum or aqueous humour. The cells are really leucocytes; but in consequence of this peculiar property, they have been termed by Metschnikoff "phagocytes." The fragments of muscle, etc., which they ingest retain their structure for some time after ingestion; gradually, however, they lose their striation, and break up into rounded, strongly refracting globules. During the atrophy of the gills in the tadpole it is easy to ascertain the presence of large, fully-laden phagocytes.

So important were these statements, that I lost no time in testing the matter so far as frogs are concerned. Having secured a number of tadpoles, individuals were preserved at various stages, and prepared for the microscope by means of Müller's fluid, etc. After the usual method of embedding in paraffin, sections were prepared of exquisite thinness, and mounted in the ordinary manner. In this way I have been enabled to follow the process in detail, and can confirm in every particular the account given by Metschnikoff. Tadpoles, at the time the hind limbs are beginning to bud, give the best result. I was led to note this carefully on account of the following observations made by Dr. Caton,* in a "Contribution to the Theory of Cell-Migration," where he points out that the migration of blood corpuscles may probably be said to have its maximum activity in the tadpole. He states that when engaged in making some observations in the month of April, the process took place to such an extent that he had some doubts that it might not be a possible physiological occurrence. The migration of the leucocytes took place more rapidly in tadpoles which were debilitated and affected with parasites from having been kept so long in a tank and fed on artificial food. This observation is important and has a very interesting bearing on the phenomena which have been just described; for there can be little doubt that this profuse migration of leucocytes, as a response to irritation, is in part physiological, but increased by the irritation.

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* "Exp. Untersuch., etc.," Wurzburg, 1875.

In the accompanying drawing (Fig. 47) is shown a transverse section of the tail of a tadpole, taken from near the tip, at the period when the limbs were well advanced. It is easy to see the phagocytes busy in their work of devouring the tissues of the tail, and their protoplasm testifies to the assiduity of their labour, for it is laden with *débris*.

It is not only in frog-larvæ that these curious habits of the leucocytes may be detected, for Metschnikoff has given an admirable description of the process, as seen in the wonderful changes which the larvæ of the echinodermata undergo in their metamorphoses, all the useless organs being eaten up by the phagocytes in this manner.

We will now proceed to further consider the experiments of the Russian naturalist. He writes :—

"Still more remarkable are the phenomena which ensue on irritating the caudal fin of a triton (newt) and other amphibians by touching the tail with a small piece of nitrate of silver and washing in salt solution, then watching the details of the inflammatory process. In this case the branched connective-tissue cells collect around the inflamed spot, and eat up carmine granules and particles of pigment.

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* "Journal of Anat. and Physiology," vol. v., p. 35, 1871.

These phenomena go to show that the essence of the inflammatory process is a struggle between the phagocytes and septic material, whether the latter be a dead or dying cell, or a fungus in a living body.

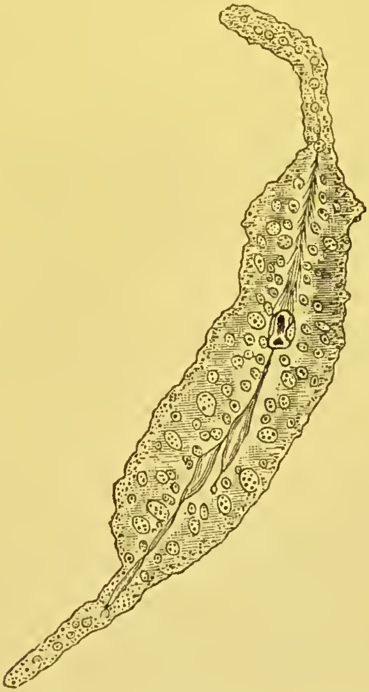

FIG. 47.—SECTION OF A TADPOLE'S TAIL.
Showing phagocytes at their work.

In a later paper, Metschnikoff drew attention to a singular disease of the Daphnia, or water-flea. He kept for purposes of observation many of these little creatures in a tank, and they became affected with spores, which gained an entrance into the body of the crustacean, germinated, and were dispersed by the blood-current over the body (it must be remembered that the blood in Daphnia, as in invertebrates generally, consists of colourless corpuscles only, which circulate in lacunar spaces), and deposited where the blood moves slowest, viz., in the cephalic and hinder portions of the mantle cavity;

in these places heaps of conidia collect. In the meantime the leucocytes do not remain idle against the invasion—they attack and devour the conidia, take them into their interior and digest them. If a conidium be too much for one cell, others join it and fuse to form a *giant-cell*, or *mesoblastic plasmodium*, to repel the invader. If the leucocytes finally overpower the spores, the Daphnia lives; if not, the conidia overrun the crustacean, and death is the result. The same thing occurs in anthrax; the white cells attack the bacilli, and digest them (see Fig. 48).

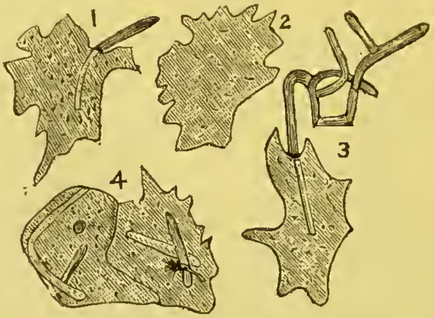

FIG. 48.

1. A LEUCOCYTE FROM FROG'S LYMPH, in the act of devouring a bacillus taken from an anthrax culture. 2. The same leucocyte, ten minutes later; it has completely surrounded the bacillus. 3. The same leucocyte, a quarter of an hour afterwards, engaging itself with a coil of bacteria. 4. The same leucocyte, fifteen minutes later, receiving assistance from another leucocyte. (After Metschnikoff.)*

Can these facts be applied to the inflammatory process as seen in mammals?

If the cornea of a rabbit be irritated by nitrate of silver or a fine silk suture, in a few hours the tissue is red and hazy, due to the presence of leucocytes which have escaped from the vessels. That the cells in the inflamed tissue are really white blood-cells may be demonstrated by the fact that if carmine granules be injected in the blood they are taken up by the leucocytes; and this serves as an ingenious means of distinguishing them in the corneal tissue.† This experiment with the rabbit's cornea demonstrates two important points —(1) that the vertebrate's leucocytes take up foreign particles in the blood; and (2) that they leave the blood-vessels to repel intruding foreign substances. Again, if a needle or fine thread be drawn through a vein, one of the first events is the collection of leucocytes around the foreign body. This swarming of the white blood-cells is an attempt, as in the case of the invertebrates, to repel the invading body.

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* "Virchow's Arch.," Bd. 97, Seit. 502, "Ueber die Beziehung der Phacocyten zu Milzbrandbacillen."

† See page 115.

Besides these facts, we know that in some forms of inflammation the white cells of the blood are notably increased. Virchow, Malassez, and Nasse have drawn attention to this matter, but the most systematic inquiry is the one made by Mr. T. P. Gostling, at the suggestion of Dr. Ringer. The results were read before the Royal Medical and Chirurgical Society, under the title, "On the Increase in the Number of White Corpuscles of the Blood in Inflammation, especially when accompanied by Suppuration." The conclusions arrived at are as follows:—

(1) White corpuscles are increased during suppurative inflammation, especially when it is accompanied by tension.

(2) They are increased in parenchymatous inflammation.

(3) They do not appear to be increased in serous or sero-fibrinous exudations.

Mr. Gostling believes the increase to be due to the absorption of leucocytes from the inflamed area in the neighbourhood of the abscess.

There is yet another histological puzzle which receives elucidation. In such diseases as tubercle, leprosy, and the so-called tuberculosis of the fowl and ox, there is a peculiar cell to be detected—the giant-cell; and in cases where bacilli have been discovered in the tissues, these micro-organisms have been found to occupy the interior of the giant-cells. In the case of tuberculosis in birds, the bacilli occupy these cells in enormous numbers. These facts seem to indicate that in the giant-cell we have the counterpart of the fusion of phagocytes as in the case of the Daphnia, and that it is really an effort on the part of the blood to rid its tissues of the noxious elements. The large multinuclear osteoclasts seen in places where vertebrate bone and teeth are undergoing absorption must also be placed in the same category.

These observations exhibit the whole process of inflammation in an entirely new aspect, and, instead of being a purely pathological process, it will rank as one of normal physiology, which, when in excess, comes within the domain of pathology. Metschnikoff says that, practically, inflammation is a struggle between irritant bodies and white blood-corpuscles.

Pus: its Formation.—When the migration of white blood-cells from the vessels is very extensive, the exudation poured out assumes a yellowish-white appearance; the fluid is then denominated pus, and usually presents the following characters. It is of alkaline reaction, with a specific gravity of about 1030. It contains various kinds of albumen, fatty matters, and inorganic substances. Examined under the microscope, it is seen to be composed of two parts—a fluid, *liquor puris*, containing large quantities of spherical, or irregular-shaped cells, varying in size from $\frac{1}{3500}$ to $\frac{1}{2500}$ of an inch in diameter: they contain usually several nuclei, rendered more distinct by the addition of acetic acid.

Although a very great deal of discussion has been carried on from time to time regarding the origin of these pus-cells, there can be little doubt that they are leucocytes which have migrated from the blood-vessels.

The various stages in the formation of pus may be traced in certain cases of pleurisy. In this disease the exudation first poured out is a fluid, agreeing in its characters with *liquor sanguinis*, and containing very few corpuscles. This collection of fluid is called "serous exudation." Later, this fluid may be pervaded with cell elements in moderate quantity; it is then said to be sero-purulent. In the third stage the exudation is so crowded with cell elements as to present a yellow appearance resembling cream. This is pus; and a pleural cavity containing purulent matter is called an empyema. If inflammatory exudation in the interior of an organ or tissue ends in the formation of pus, it leads often to the liquefaction and dissolution of the tissues, and a pus-containing cavity, or abscess, is formed. An abscess may form in any tissue or organ containing blood-vessels, be it soft, as muscle or brain, or hard, like bone. Hence an abscess may be defined as a collection of pus in any organ or tissue of the body. Such a collection may vary from an amount requiring the microscope to reveal its presence, to a quart, or even more.

It has been stated that the fluid and cells exuded into tissues during an inflammatory attack may, on the subsidence of the irritation, be reabsorbed into the circulation, partly by the blood-vessels, and partly by the lymphatics. This constitutes recovery. To this absorption process there is often a limitation; circumstances may arise and check the removal of the inflammatory material. It now becomes our duty to ascertain what becomes of the effused products.

If they have become transformed into pus, a common result is condensation, due to the absorption of water. The cell elements undergo fatty change, they shrink, and break up till nothing is left but an irregular granular amorphous detritus; because the resulting mass has a cheesy appearance the condition is spoken of as cascation. The mass in some cases has salts of lime deposited in it; this is termed cretification or calcification. These masses may remain encysted in the body for years, and may never give any further trouble.

In cases where the inflammatory process has been so severe as to lead to death of the tissue affected, the necrosed portion is no longer part and parcel of the organism, and attempts are now made to rid the body of the offending substance. If the dead portion or sequestrum be small, the leucocytes attack and endeavour to devour it; thus pieces of moderate size may be effectually destroyed. If large, however, the whole process is very considerably modified, and was considered in the chapter on Necrosis (page 99).

If we summarize the story of inflammation as we read it zoologically, it should be likened to a battle. The leucocytes are the defending army, their roads and lines of communications the blood-vessels. Every composite organism maintains a certain proportion of leucocytes as representing its standing army. When the body is invaded by bacilli, bacteria, micrococci, chemical or other irritants, information of the aggression is telegraphed by means of the vaso-motor nerves, and leucocytes rush to the attack; reinforcements and recruits are quickly formed to increase the standing army, sometimes twenty, thirty, or forty times the normal standard. In the conflict, cells die, and often are eaten by their companions; frequently the slaughter is so great that the tissue becomes burdened by the dead bodies of the soldiers in the form of pus, the activity of the cell being testified by the fact that its protoplasm often contains bacilli, etc., in various stages of destruction. These dead cells, like the corpses of soldiers who fall in battle, later become hurtful to the organism they in their lifetime were anxious to protect from harm, for they are fertile sources of septicæmia and pyæmia—the pestilence and scourge so much dreaded by operative surgeons. The analogy may seem to many a little romantic, but it appears to me to be warranted by the facts which have been placed before the reader.

CHAPTER VIII.

INTERSTITIAL INFLAMMATION.

IF violence be offered to the tissues of the body, it may be so severe as to cause the death of the part injured; short of this, it will most probably induce the phenomena described at the commencement of the last chapter. Under such conditions, the inflammation is commonly described as *acute.* If the inflammatory process be not severe, but long continued, it is designated *chronic*, and often *interstitial*, as distinguished from *parenchymatous* inflammation. There is no other distinction in the process in the two forms, except one of degree; but the division is a very useful one, for it enables us to briefly indicate the seat of the inflammation in compound organs or structures, the term interstitial referring to the fibrous framework of the organ. Thus in the lungs, croupous pneumonia refers to inflammation affecting the air-cells, whilst the interstitial form affects mainly the connective tissue of the lungs. Frequently, but by no means always, parenchymatous inflammation is acute; the opposite variety is always chronic; and there is abundant good evidence to show that a large quantity of new-formed fibrous tissue, which arises under such conditions, is in part owing to multiplication of pre-existing connective-tissue elements, and in part due to organization of products exuded as a result of the inflammatory process. As the process plays a very important *rôle* in pathology, it must be considered in some detail.

In man, in this country at least, interstitial inflammation may be best studied in the liver. In this organ it is usually recognized under the term cirrhosis, or interstitial hepatitis. The causes of chronic interstitial hepatitis reach the liver by various routes. Thus many noxious agents absorbed from the alimentary canal, especially alcohol, have an important influence in its production; in other cases syphilis is recognized as a cause, whilst in other instances the bile-ducts are the chief channels.

The early stages of the affection are marked by the presence in the liver-tissue of leucocytes, which are most abundant in the interlobular connective tissue. At first the infiltration occurs in patches, which may become gradually confluent, and be diffused throughout the organ.

It becomes an interesting question to determine whether this new production of connective tissue is the direct result of the proliferation of that already existing, or is in any way dependent on the migrated leucocytes. There is abundant good evidence to lead us to believe that the leucocytes undergo further development, as the following clear account given by Ziegler shows. He made small chambers of slightly separated cover-glasses, and introduced them into the subcutaneous tissues of dogs, and removed them at different periods. The contents could thus be examined microscopically: from the single layer of cells thus obtained the following conclusions were drawn:—

There were always cells undergoing progressive changes, as could easily be observed; cells could be found in all stages of development, and the actual formation of tissue could be traced. When large cells were formed, a certain number of round cells in the neighbourhood disappeared, as though their protoplasm was appropriated by the growing cell. The stages from the simple leucocyte to formed tissue are thus traced in Fig. 49:—A, represents migrated leucocytes; B, their elongation into formative cells, which contain a large vesicular nucleus; these cells are known as epithelioid. A growing cell may appropriate the substance of others which are decaying; two of them may coalesce. It is these cells which have the power of forming new connective tissue, hence they may appropriately be termed *fibroblasts.**

From this it will be obvious that the process in the liver, in this form of inflammation, is closely akin to that by which breaches in the continuity of soft tissue are repaired.

In such an organ as the liver, this overgrowth of interstitial tissue, when in large amount, exerts a disastrous influence, for it invades the lobules, compressing and destroying the liver-cells, whereby the function of the gland is very seriously impeded.

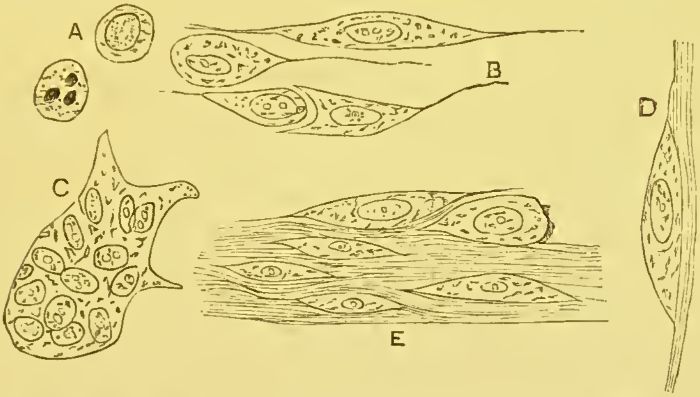

FIG. 49.—GRANULATION-CELLS IN VARIOUS STAGES.

A, migrated white blood-cells ; B, uninuclear formative cells ; C, multinuclear formative cell ; D formative cells developing connective tissue ; E, developed connective tissue. (After Ziegler.)

In the early stages of this disease the liver is larger than usual, and remains so as long as the new-formed tissue more than counterbalances the atrophy of the hepatic cells; but as a rule the atrophy of the cells and the shrinking of the fibrous tissue lead to a great diminution in the size of the organ, and serious consequences to the individual.

The phenomena presented by interstitial inflammation in the liver hold good for other organs. In the lungs it is recognized under the terms *interstitial* pneumonia, *cirrhosis*, *fibrosis*, etc.; but in all cases it is the same fundamental process, chronic irritation, slow inflammation, leading to the gradual production of nuclear, fibroid, or interstitial tissue, as it is variously styled, which as gradually invades and destroys the essential tissue of the lungs.

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* Ziegler: "General Pathology," vol. i., p. 151.

The chief causes of this fibrosis of the lungs are the inhalation of irritating vapours and dust, such as occur in needle grinders, flax dressers, coal miners, masons, and the like. It also occurs as a sequel to acute inflammation of the lungs (croupous pneumonia), and in some rare cases as the result of invasion of tissue from the pleura in chronic pleurisy. In the kidney, it may be a sequel of acute nephritis, or provoked by chronic irritants, as in lead poisoning, gout, alcoholism, etc., the interstitial tissue increases in amount, and leads to the destruction of the tubules and Malpighian bodies, ending in shrinking and total disorganization of the organ, and often arresting the life of the individual.

As in the corresponding changes in the liver, lung, etc., the aberration in the kidneys consists in cellular infiltration of the inter-tubular connective tissue, but the change is usually best observed in the neighbourhood of the glomeruli, and in all cases the changes are best marked in the cortical regions. It is curious that the arteries of the limbs undergo a similar change, whereby their middle coats become very much thickened. Like changes occur in the heart, whereby the contractile tissue of this important organ suffers, and leads often to the sudden death of the individual in whose heart such changes occur. The alteration is characterized by the development of a fibrillated tissue between the muscular elements. The process appears to begin in the intermuscular septa, by an infiltration of small cells, which vary considerably in quantity, and which tend to develop into connective tissue, the muscular fibres themselves undergoing atrophy as a result of nutritive interference due to this overgrowth of fibrous tissue. In very many cases this fibroid induration of the heart, as it is termed, appears to be induced by inflammatory processes commencing in the peri- or endocardium. In some instances syphilis would seem to be a factor in its production.

In some examples, according to Fagge,* the walls of the heart no longer present to the naked eye any indication of containing red muscular tissue, but are formed of a white tough material, looking very like tendon. This observer, besides pointing out the frequency of this condition in obscure cases of sudden death, also states as his opinion, that probably aneurism of the heart is to be attributed to this cause. The frequent connection between cardiac aneurism and fibroid degeneration of the muscle fibre of the heart has been noticed by several writers.

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* "Trans. Path. Soc.," vol. xxv., p. 64.

In one curious instance which came under my observation, in the heart of a small deer, the moderator band, which normally connects the opposite walls of the right ventricle, had undergone conversion into tendon; no trace of muscular fibre could be detected. It is also well to bear in mind that the valves of the heart and chordæ tendineæ are, in their first development, composed of muscular tissue.

In bone, as a result of long-continued inflammation, the affected tissues become infiltrated with exudation products, which in many cases undergo transformation into osseous tissue. Such bone is characterized by extreme hardness, weight, and an increase in the number of lacunæ. The condition is usually referred to as sclerosis. The process by which this change is brought about may be readily studied in cases of rickets, during the progress of the disease. In very severe cases, particularly those occurring in monkeys, it is easy to trace into the compact tissue of the shaft of the bone, thin lamellæ of young fibroid tissue, during the later stages, but before the fibrous ingrowths have begun to ossify. This new tissue becomes converted into exceedingly dense bone, that is, providing the animal recover from the effects of the disease.

In the nerve-centres the delicate interstitial tissue known as neuroglia takes on the same chronic overgrowth, strangling the nerve-strands and cells, giving rise to the most singular and complicated nervous phenomena that the physician is called upon to unravel. The changes thus produced are recognized by the general term *sclerosis*. The situation of the sclerosis, of course, determines the name assigned to any particular group of symptoms. Thus, if it affects the fasciculus of Burdach and the columns of Goll, locomotor ataxia results; if the lateral columns, lateral sclerosis; if the medulla, bulbar paralysis, and so on.

With regard to animals, an interesting case is reported by MM. Weber and Barrier in the "Recueil de Médecine Vétérinaire," Juillet 15, 1885. The case occurred in a young horse, and the details of the symptoms and post-mortem examination were worked out at the Veterinary School of Alfort.

The signs during life were strongly suggestive of locomotor ataxia, and the appearance of the cord after death revealed the existence of tracts of sclerosis in the cervical and lumbar regions of the cord.

Mr. Victor Horsley has recently demonstrated that the affection known as canine chorea depends on disseminated sclerosis of the spinal cord, thus proving what many had previously suspected. Recently I communicated to the Pathological Society a case of sclerosis in the spinal cord and nerves of a Civet cat affected with perforating ulcer, and have since dissected an example of this disease in a Paradoxure.

Fibroid changes, the result of interstitial inflammation, may be detected in the testicle. In this organ, from various causes—injury, inflammation from extension, scrofula, tuberculosis—an increase in the intertubular connective tissue takes place, and in all respects resembles that which has previously been considered. So that whatever ultimately becomes of this new-formed fibroid tissue, complete organization or breaking down, it arises in a similar manner, as the result of certain processes, the outcome of chronic inflammation.

In the voluntary muscles, similar changes occur in that curious disease known as pseudo-hypertrophic paralysis, which chiefly affects children. In this instance the connective tissue between the muscle-fibres increases so much above the normal, that the muscles affected may exceed their usual thickness three times. Later, however, the new tissue shrinks, and the contractile substance of the muscle becomes destroyed or replaced by fibrous tissue.

This disease is an interesting one, for careful observations go to show that during the active stages of the affection the temperature of the limb is somewhat raised. This is very important, for it clearly shows that the process is essentially one due to inflammation.

The curious nature and origin of the peculiar tissue described in the preceding sections as *fibroid* has been the source of much dispute among pathologists. Some ascribe its origin to increased activity on the part of the pre-existing connective tissue; others attribute its formation to the lymphatics; and according to other observers, it is derived from the exuded leucocytes. There can, I think, be little doubt in the minds of any who have worked impartially at the question, that in almost all cases where the production of this tissue is excessive, chronic inflammation has been at work, and that in most cases the chief source of this translucent tissue is the emigrated leucocytes. The most favourable conditions for studying the formation of this fibroid tissue, and to watch its transformation, are those cases in which foreign bodies, parasites, bullets, etc., are lodged in the body, and encysted.

If a clean bullet or metallic substance lodge in the body, its presence is at once resisted by the leucocytes, and a zone of inflammation is established around it. This is followed by the development of granulation tissue, which at length assumes a fibrous texture. As the substance resists absorption, it becomes encapsuled or encysted, and may remain in this condition throughout the life of the animal. It is no uncommon thing to find shot embedded in the tissues of animals, in the bones as well as in those of softer texture.

That the leucocytes endeavour to remove foreign bodies is shown in cases where the skin of the arm has been tattooed; in old-standing cases the minute particles of pigment will be found in the axillary glands, and in some cases the pigment has been carried away in such quantity that the lymphatics show evidence of pigmentation along their whole course.

When an embryo-hydatid or fluke gains entrance into the substance of an organ like the liver, a zone of inflammation is set up in the same way as around a foreign body; but the living tissue of the parasite resists absorption as does a bullet or piece of glass.* Instead of the inflammatory products being absorbed, they organize and surround the intruder with a thick wall of fibroid tissue. In the same way trichina spiralis may become encysted in a muscle, the fibrous formation being later impregnated with salts of lime (calcification).

The behaviour of the tissue to foreign bodies reminds one of the resentment of bees to any insect intruding or trespassing into their hive. If the offender be small, they sting him to death and quickly turn him out. If large, and they succeed in depriving it of life, it may be too heavy for them to remove, they then set to work and cover the dead body with wax, thereby rendering the carcase innocuous.

In the hard tissues—bone, for instance—the process is precisely the same. Foreign or noxious particles, such as sequestra, etc., often become locked in, and by the chronic irritation they give rise to, lead to the condensation of the osseous tissue, which completely encysts and locks in the offending material. Thus abscesses have remained confined in bones, after this fashion, for many years.

The teeth of the elephant afford excellent opportunity for us to study the mode by which foreign bodies may become encysted in such dense structures. The incisors (tusks) of the elephant grow from persistent pulps, and like the teeth of rodents, increase in length throughout the lifetime of the animal. If, as often happens, a bullet or other missile enters the pulp-chamber, the latter becomes irritated, and the inflammation established in consequence gives rise to the formation of a peculiar variety of hard tissue known as osteodentine, which encapsules the bullet, spear-head, or iron slug, as the case may be, and no more harm results. The encysted process completed, the foreign body gradually passes on with the growth of the tusk until it escapes at its free end in the way represented in Fig. 50.

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* See also the experiments described on p. 130.

The mode by which the encysting process is accomplished was first fully made out by Goodsir. He showed the bullet was surrounded by a tissue which differs from dentine in that it is made up of a series of tufts of confused tubes, without any definite arrangement, mixed up with spaces like the lacunæ of bone or interglobular spaces in teeth, and vascular canals. This substance is now recognized as osteo-dentine. Outside this anomalous tissue is found the normal regular ivory (dentine).

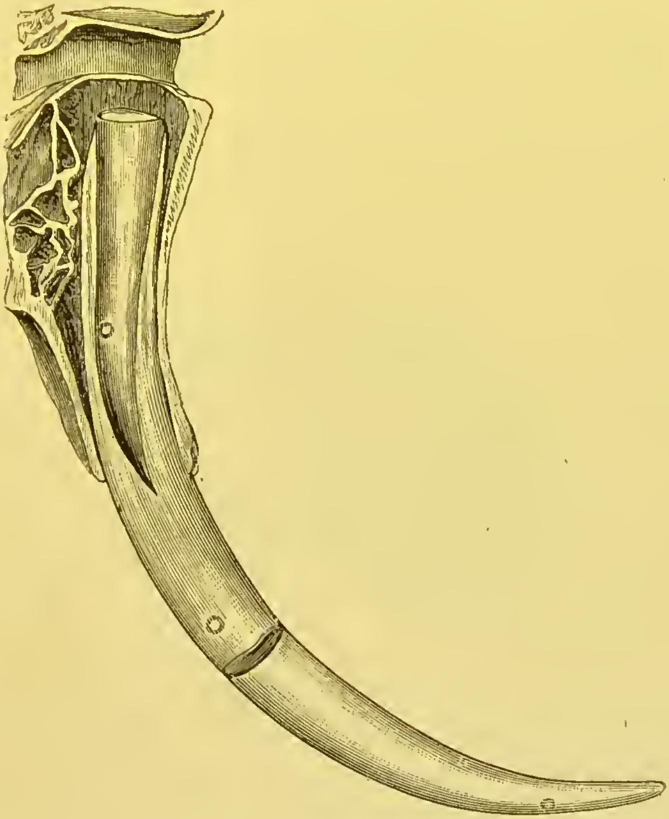

Fig. 50.—The Tusk of an Elephant.

Showing the mode by which bullets gain entrance to the pulp-chamber, become encysted, and eventually worked out. (Modified from Owen.)

Osteo-dentine, as in so many other examples of tissue formed in disease, contrasts widely with the regularity of dental tissues formed in health.

Mr. Alexander Nasmyth was the first to point out the resemblance of this substance to that which fills the pulp-cavity of the human tooth under certain conditions. Thus it may occur in the teeth of the aged, in whom the pulp-chamber is often much contracted in size; and it is by the formation of this substance that the pulp protects itself when threatened by the approach of dental caries. The same tissue, osteo-dentine, forms a large portion of the teeth of certain cetacea.

This called forth a special remark from Goodsir:—"This identity of diseased structure in one animal with a normal structure in another, is remarkable, and must be looked upon as another instance indicating the existence of a system of laws regulating the relations between healthy and morbid tissues."

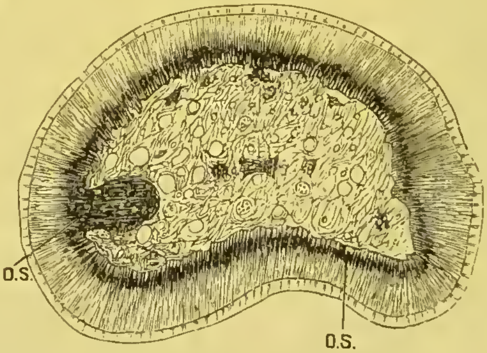

FIG. 51.—SECTION OF A CAPYBARA'S TOOTH.
To show osteo-dentine produced by disease.

The history of our knowledge regarding foreign bodies embedded in the teeth of elephants is a very interesting one, for it serves to illustrate the way in which facts, merely recorded for their curiosity, later assume considerable scientific importance.

Haller refers to the circumstance of foreign bodies in teeth in his "Elementa Physiologiæ."

Klockner mentions a gold ball which was found by a turner of Amsterdam in the substance of an elephant's tusk. Camper cites the case of a bullet impacted in a tusk, and remarks that it is not unusual to meet with these foreign bodies in ivory.

In 1808, Cuvier noticed the presence in the tusks of elephants of foreign bodies, and that the ivory outside the ball was natural, but that immediately surrounding it was irregular. He supposed the ball to penetrate the very thin bases of the tusks in young elephants, so as to enter the pulp when in a growing state, as the following passage clearly shows :—

"C'est que la balle avait traversé l'alvéole et la base encore mince de la défense d'un jeune éléphant, et s'etait logée dans le noyau pulpeux, encore dans tout son develloppement."

Blumenbach had a tusk of this nature in his collection, which showed traces of a cicatrix closing the entrance made by the foreign body, and deduced therefrom a property in the elephant's tusk to pour out bony matter in order to heal such wounds.

Cuvier clearly showed that the substance surrounding these impacted bodies differed from true ivory, and this was the keynote to the explanation of the mystery. The nature of this osteo-dentine was fully investigated by other observers, particularly Owen, and Mr. Alexander Nasmyth pointed out the resemblance of this substance to that which fills the pulp-cavity of the human tooth under certain conditions. In 1841, Mr. Goodsir published a very interesting and comprehensive memoir on the subject, in the "Edinburgh Philosophical Transactions." He divides injuries of the tusk into three classes :—

(1) When the ball hits the free portion of the tusk, if it only penetrates to a certain depth of the ivory, no change takes place.

(2) Those cases in which the ball enters the pulp-cavity through the socket and side of the tusk, the ultimate changes being, in favourable cases, the formation of osteo-dentine, the enclosure of the offending body, and obliteration of the breach in the side of the tusk. Gradually the tooth advances in the socket, and eventually the foreign body arrives at a sound portion of the tusk.

(3) When a foreign body enters from above through the open end of the pulp-chamber without wounding the tusk.

The entrance of a bullet is readily understood, as the great force by which these deadly missiles are propelled easily carries them through most animal structures; but not so with regard to spear-heads, the occurrence of which in the middle of tusks is beyond question. Mr. Charles Tomes gives a very intelligible explanation of an instance of impacted spear-head, as follows:—

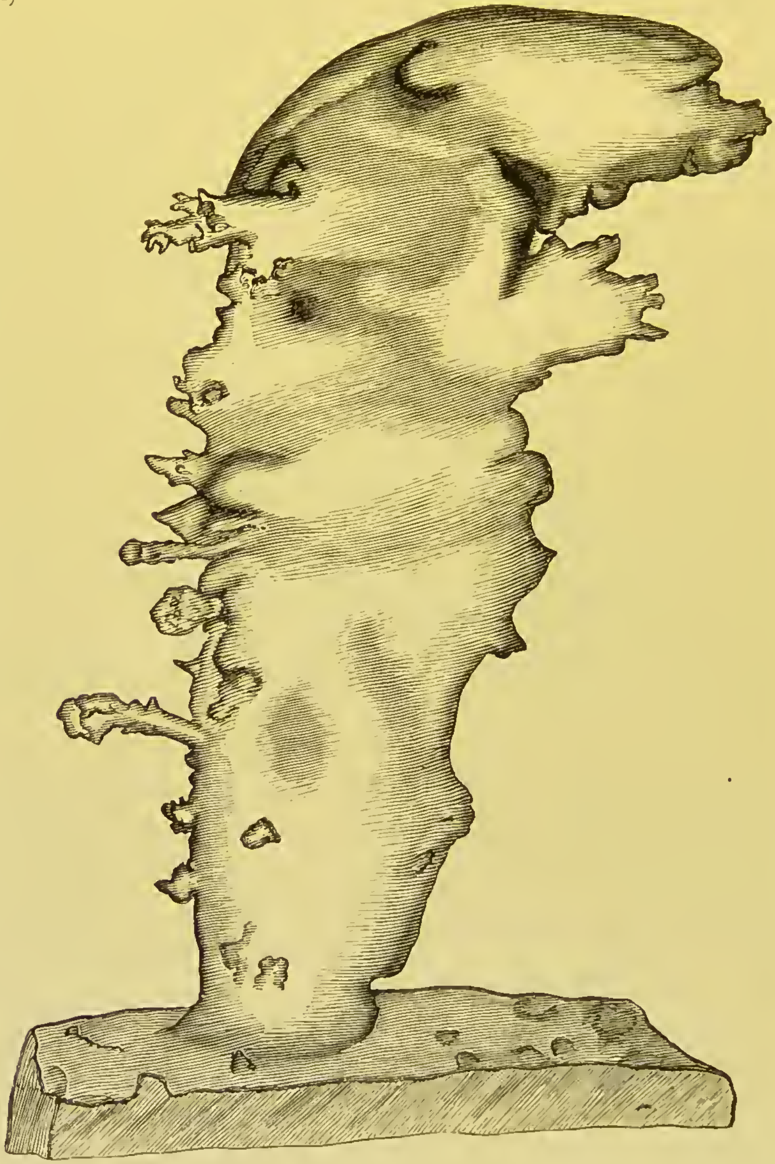

Fig. 52.—A large Mass of Osteo-dentine occupying the Pulp-Cavity of an Elephant's Tusk. (College of Surgeons' Museum.)

"It is to be presumed that a heavily loaded spear was dropped by a native from a tree, with the intention of its entering the brain, upon the elephant as it was going to water. But in these cases the spear penetrated the open base of the growing tusk, which looks almost vertically upwards, and then the iron point appears to have broken off: this did not destroy the pulp, but the tooth continued to grow, and the iron point, measuring no less than 7½ by 1½ inches, became so completely enclosed that there was nothing upon the exterior of the tusk to indicate its presence."*

The museum of the Royal College of Surgeons contains several excellent examples of foreign bodies enclosed in elephants' tusks, and the museum of the Odontological Society has also some good specimens of this condition—among them an example of a bullet in the molar of an elephant.

Fig. 52 represents a large mass of osteo-dentine found in the pulp-chamber of an elephant's tusk. In the drawing it is represented of nearly natural size.

From observations conducted on diseased teeth of mammals there is every reason to believe that osteo-dentine is not in any way related to dentine except that it occurs in teeth. Osteo-dentine results from the ossification of the connective tissue of the pulp of the teeth. In very many cases it may be preceded by inflammation, but that event is by no means essential for its production.† In diseased teeth it is the result of interstitial inflammation, as in Fig. 51.

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* "Dental Anatomy," p. 322.

† "Trans. Odonto. Soc. Great Britain," Feb. 1886.

LEEDS & WEST-RIDING
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CHAPTER IX.

LESIONS RESULTING FROM SPECIFIC IRRITANTS.

An irritant may be defined as *anything which, when brought into contact with living material, is capable of exciting inflammation.* The inflammation thus set up may be of two kinds, according to the nature of the irritant. It may be *simple* or *specific.*

By a simple inflammation is understood such as commonly follows mechanical, thermal, or chemical stimuli. A specific inflammation results from the introduction into the organism of a particular poison or irritant, such as variola, glanders, tuberculosis, syphilis, actinomycosis, and the like.

The effects of simple irritants, mechanical and thermal, will not be further considered, but attention will be especially devoted to the specific ones. That the effects of inflammation vary with the irritant, no one can deny. Dirt on a child's hand produces warts; decaying animal matter, when handled, causes in some cases veruca necrogenica, and soot gives rise to the soot-wart, or epithelioma.

The most striking examples of the effect of a specific virus in giving rise to inflammation, presenting characters peculiar to that virus, is well shown in the curious group of pathological formations known as the infective granulomata. The group includes tuberculosis, leprosy, syphilis, glanders, actinomycosis, and the like. This group of affections appears to be due to the invasion of the body by a virus or poison derived from the outer world, or from the body of another individual.

The essential features of the lesions are the following:—Microscopically they exhibit the characters of granulation-tissue—that is, a soft tissue made up almost entirely of round cells, with very little intercellular substance. It is one of the characters of this tissue that it should go on to form cicatricial tissue; but in the case of the infective granulomata, the elements stop short of this stage, may persist for a time unmodified, frequently develop to a considerable amount; it then gives way to retrogressive changes, this last being due to the poverty of the growth so far as regards blood-vessels. Their infective character is manifested in the following manner:—They are locally invasive, the granulations spreading to surrounding structures. Whilst spreading at the periphery, the centre of the growth dies and disintegrates. It may affect the lymphatics, and being transferred from thence to the blood, may affect more or less the entire system.

Their infectiveness is most pronounced when they are inoculated or transferred from one individual to another.

The credit of insisting on the likeness these growths bear to the products of inflammatory processes belongs to Virchow. He described their chief characteristics as "failing to develop beyond the stage of granulation-tissue, their unstable condition and proneness to ulcerate." Recent investigations have thrown further light on this matter, in the discovery of the constant association of micro-organisms with the characteristic nodular formations.

Tubercle and Tuberculosis.—Tuberculosis is an infective disease, characterized anatomically by the formation of minute nodules—tubercles—which nodules may occur in an isolated manner, or by their confluence form larger or smaller conglomerate masses.

When fully formed, a true tubercle may be described as a small grey translucent nodule, not exceeding a millet seed in size (it must be borne in mind that all minute translucent nodules are not tubercles, as is too often supposed). Histologically, tubercles in their most typical form are characterized as follows :—

Each fully-formed nodule consists of an abundant collection of round cells, enclosed in a delicate fibrillar meshwork or stroma; inside this zone a collection of larger nucleated epithelioid cells may be distinguished, and lastly in the centre a plasmodium (giant-cell).

Such a structure as this can be made out in certain other infective granulomata; indeed there is nothing in these appearances which can be definitely stated as absolutely peculiar to a tubercle. It was at one time thought that the plasmodium (giant-cell) was a specific character of these growths, but later researches have established its fallacious character in this respect.

Koch's admirable researches among micro-organisms have rendered it exceedingly probable that these minute nodular lesions are the direct result of a particular virus, the *Bacillus tuberculosis*, a minute rod-like body, about 0·003 millimeter in length, its breadth being one-fifth or one-sixth of its length. These bacilli are found chiefly in fresh tubercles, more sparingly in old ones; they not only lie among the cells, but also in them, especially in the plasmodia. They may be found singly and scattered, or more or less in clusters. In some cases, more particularly in animals, the clusters may be so large as to be visible, when stained, to the naked eye. The most striking feature of these bacilli is their reaction to certain staining re-agents. If tissue suspected to contain these micro-organisms be treated with methylene blue and vesuvin, the bacilli take on a different tint from the surrounding tissues. Those tissues stained in the first instance with the methylene blue have their colour discharged by the vesuvin, while the tubercle bacilli retain it. Simpler methods have been devised; that by Gibbes is especially satisfactory, and is capable of ready application. Not only did Koch prove the constant occurrence of these bacilli in tubercular lesions, but he cultivated them in the serum of ox blood, and by other methods used for such cultivations. The products of these cultivations were introduced into the bodies of various animals (rabbits, rats, dogs, and monkeys), and tuberculosis was thereupon induced, the nodules exhibiting the distinguishing features of tubercle, and always containing the characteristic tubercle-bacilli.

According to Koch, the bacillus can only be cultivated between the temperature of 86°—105° Fahr.

When the nodule becomes older, its centre invariably caseates, becoming yellowish-white and opaque. Microscopically it appears as a granular friable mass; but at the periphery it still exhibits a cellular constitution. This peculiar disposition to caseation is usually explained thus:—

The tubercles are ill supplied with blood-vessels, and can only attain a certain size and perish. The central cells, being farthest removed from the nutrient stream, degenerate first, becoming soft, opaque, and caseous. In situations where tubercles become confluent, larger and more irregular masses are formed. Lime salts may be deposited in these caseous patches, and the mass become cretified. Occasionally the tubercular nodule may cicatrize, the granulation-tissue passing into fibrous or cicatricial tissue.

Almost invariably there occurs in the vicinity of a tubercle some reactive inflammation, which leads to the formation of adventitious tissue other than that resulting from the primary irritant—the bacillus.

Perlsucht.—Closely allied to, but in certain respects differing from, human tubercle, are the nodules found in a frequent disease of cows and other ruminants, known as bovine tuberculosis, or better, perlsucht. It is familiar to dairymen as the grapes or duckweed. The disease was thought at one time to be confined to cows, but it has been found in deer, the nylghie, reindeer, pronghorn, camel, and llama.

Histology of the Pearly Nodules.—Inasmuch as the macroscopical characters of the nodules, wherever they occur, agree in their liability to caseation and cretification, so do the lesions harmonize in the details of their microscopic characters.

In the early stage—and this is really the only one suited for making out their histological details—we find them made up of round cells, mixed with multinuclear cells (giant-cells). After particular preparation, bacilli of peculiar characters may be detected. For this addition to our knowledge we are indebted to the laborious investigations and genius of Koch. These fine bacilli come out particularly well after staining with methylene blue and vesuvin; some possess bright oval spores, some smooth and homogeneous-looking, others present a beaded appearance. In the caseous masses of perlsucht they are especially abundant, and Koch found them form a more or less regular zone in the peripheral portions of the giant-cells, but by-and-by they disappeared from these cells.

Dr. Klein concludes from his observations and experiments that the bacilli of human tuberculosis and perlsucht are not identical, as stated by Koch. Klein finds that the bacilli in the two diseases are different in their morphological characters, and in their distribution. The bacilli of human tuberculosis are one-third as large again as those found in the caseous masses of perlsucht, and in many instances more regularly granular. The bacilli in the lungs of cattle are always contained in cells; the larger the cell the more numerous the bacilli. When the cell · disintegrates, the bacilli become free in groups. It does not require much experience to enable one to detect a difference between the bacilli of the two diseases.

Avian Tuberculosis.—In this affection the alimentary canal and liver are occupied with nodular lesions, varying in size from a minute speck, to a mass as large as a walnut. Microscopically these masses are made up of round cells, pus-cells, and the large multinuclear or giant-cells. These lesions contain bacilli in great numbers, indistinguishable from those held to be characteristic of tuberculosis; but in the way the bacilli are related to the cells of the growth, they resemble leprosy. Referring to this disease in the rhea, Dr. Klein draws attention to the characters of the bacilli, and regards this affection as leprosy; but it is obviously a mistake, the two diseases having no feature in common except bacilli. For full details of this curious disease, see "Path. Soc. Trans.," vol. xxxv., p. 477.

Leprosy.—This remarkable affection also comes under this category. It is a disease anatomically characterized by the formation of nodules or tubers in the tissues. These nodules are made up of granulation-tissue lying immediately beneath the epidermis; this consists of small round cells, like leucocytes, and some very large ones—lepra-cells.

Recently a bacillus has been detected in the lesions of this disease. In some cases these minute bodies are present in great numbers, and bear a remarkable similitude in size, appearance, and behaviour with staining re-agents, to the bacillus tuberculosis. For an excellent figure of lepra-cells and bacilli, see "Path. Soc. Trans.," vol. xxxiv., p. 289.

Actinomycosis.—Actinomycosis may be defined as a progressive inflammatory affection characterized by the formation of granulomata, which may occur in various parts of the body, but is most common in the mouth, set up by a certain fungus, the actinomyces. The lesions are exceedingly liable to suppurate. The disease usually attacks cattle, but may spread from them to human beings,* pigs, and sheep. It may be communicated to cattle by inoculation.

The Actinomyces.—When one of the nodules developed in the course of this disease is examined under the microscope with a low power it presents a radiate arrangement. Properly prepared, as by staining with Spiller's purple and examined under a high power, it will be found composed of a kind of capsule of fibrous-looking tissue, having inside this a collection of cells resembling lymphoid cells; approaching the centre the cells get larger, and occupying the middle of the mass is the cluster of actinomycetes, presenting an appearance described by Ziegler as that of a "tufted rosette of radiating pyriform or club-shaped structures." These club-shaped structures are regarded as the conidia of the fungus. When fully developed, the tuft has an appearance resembling that of a mulberry (Fig. 53). The centre is regarded by some as a mycelium, and the radiating tufts as the conidia. When the fungus settles in a tissue it gives rise to inflammation, and while the spore is developing its mycelium an inflammatory nodule forms around, and has very much the look of a tubercle.

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* See a case by Mr. G. S. Shattock "Path. Soc. Trans.," vol. xxxvi., p. 254.

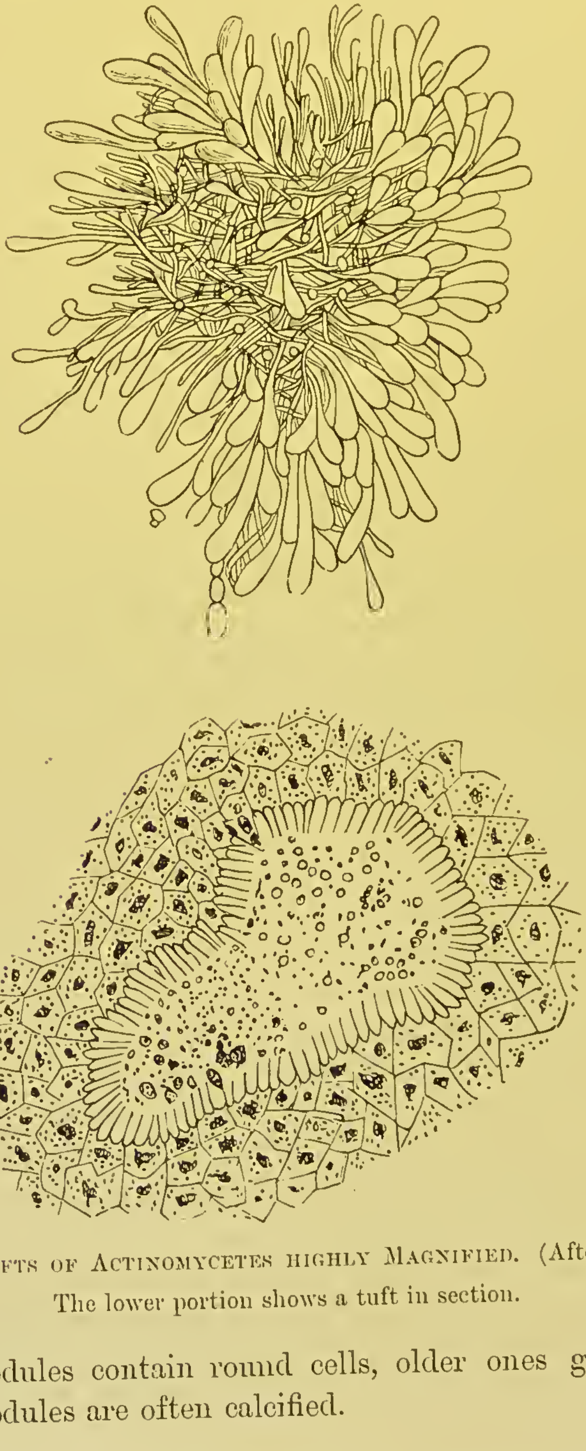

Fig. 53.—Tufts of Actinomycetes highly Magnified. (After Fleming.) The lower portion shows a tuft in section.

Recent nodules contain round cells, older ones giant-cells, and old nodules are often calcified.

Small nodules may become confluent and give rise to a tumour of the size of an orange, but their tendency is to break down and suppurate. Hence large masses always contain pus-cavities, and are riddled with fistulæ.

Syphilis.—This disease presents, in the lesions manifested by it, all the characteristics of similar nodules formed under the influence of some irritant. Although many attempts have been made to isolate a specific bacillus for this affection, they cannot yet be regarded as satisfactory. Up to the present time the disease has not been found in any animals; it seems to be exclusively confined to man. Many attempts have been made to inoculate monkeys, but the experiments have only been attended with partial success.

Lupus.—This affection belongs to the group of lesions resulting from the action of some specific irritant. Some pathologists maintain that it is a form of tubercle, and due to the same bacillus as tuberculosis.

Glanders.—This is a contagious disease, directly communicable from animals to man. The affection known as farcy is the same disease as glanders, the only difference being that the former principally affects the skin, the latter manifests itself chiefly in the nasal mucous membrane. The lesions characteristic of this disease present similar features to those just described, and though the nature of glanders poison is unknown, the histological characters of the lesion strongly support the view that it is the result of some specific irritation. The reader should consult any work on veterinary medicine, where full details of this dreaded equine disease are given in full. Instances of the occurrence of glanders in human subjects are rather uncommon, and there is no essential difference in the histology of the lesions in man as compared with those of the horse.

In addition to these forms, attention must be drawn to nodular lesions found in animals and birds as a result of the introduction into their organs and tissues of such things as the trichina, coccidia oviforme, and various similar organisms. In these cases the presence of the foreign bodies gives rise to inflammation, and an attempt is made on the part of the leucocytes to destroy them. These exuded leucocytes become later transformed into inflammatory tissue, varying in slight detail according to the irritant which starts it. As a result, nodular lesions of different size and shape arise, but in all cases irritation leads to the formation of tissue which is very unstable, liable to necrotic changes, and when it organizes cannot give rise to anything more advanced than cicatricial tissue.

The characteristic features of the diseases considered in this chapter seem to be a struggle between irritant particles and corpuscles, exactly as in the case of inflammation—the lesions produced in individual cases varying with the irritant.

CHAPTER X.

TRANSPLANTATION, Etc.

The term transplantation, as commonly applied in pathology, is confined to those cases where, by the intervention of the experimentalist or surgeon, portions of tissue are transferred from one animal to another, from man to man, or from an animal to man, or it may be from one part to another of the same individual. In this work the term will include not these instances merely, but also certain examples of transplantation which are not due to the intervention of art.

It has long been known that portions of dermal tissues, when completely detached and transplanted to other parts of the body, occasionally retain their vitality, and become incorporated with the surrounding tissues.

Thus, in the historically interesting experiments of Hunter, spurs were cut from the legs of fowls, and transplanted into their combs, where many of them formed vital attachments and grew.

In other instances this great observer transplanted teeth into the combs of cocks immediately after extraction. The fangs of the teeth united intimately with the surrounding substance of the comb, and by injection of the blood-vessels of the head, vessels could be demonstrated passing from those of the comb into the pulp of the tooth. Hunter also experimentally demonstrated the fact that teeth may be successfully transplanted in the human subject, which has since been abundantly proved.

Perhaps one of Hunter's most curious experiments is the one now to be described:—

"Here is the testicle of a cock, separated from that animal and put through a wound made for that purpose in the belly of a hen, which mode of turning hens into cocks is much such an improvement as that suggested by Dean Swift when he proposed to obtain a breed of sheep without wool. The hen was afterwards killed, and the testicle was found adhering to the intestines." "Hunter's Lectures: Works," vol. i., p. 391.

A new interest was added to these experiments when Reverdin pointed out that by means of transplanted portions of skin, large granulating surfaces could be induced to heal. The fact that small pieces of skin, when transferred to a granulating surface, will grow, is put to almost daily practice by surgeons, to cause stubborn ulcers to cicatrize. Not only is skin thus capable of being transplanted, but bone, nerve, muscle, and even such tissues as tendon and cornea have been successfully grafted.

Gluck,[*] in some interesting experiments on the transplantation of tendon and muscle, has succeeded in removing muscle and tendon from rabbits, and implanting them in hens, and with such success that the introduced tissue, after a time, responded to electrical stimuli applied to the dominant nerve of the muscle containing the intruded tissue. In the same way he has demonstrated the feasibility of transplanting portions of nerves.

M. Bert[†] grafted the tip of a rat's tail into its back, and after a time cut the tail from its normal point of attachment. A year subsequent to the operation, irritations of the end of the tail were felt as pain, so that its sensitive nerves, now in union with dorsal nerves, must have carried impressions in a reverse direction.

With regard to bone, Ollier succeeded in producing osseous tissue by transplanting portions of the periosteum in such animals as the rabbit, cat, dog, and others. But one of the most remarkable examples of transplantation of bone is that recorded by Macewen, in "Proc. Royal Society," vol. xxxii. In this instance a boy, aged three years, was admitted into the Glasgow Infirmary suffering from necrosis of the entire diaphysis of the humerus. After the removal of the sequestrum, the periosteum failed to develop bone, and Macewen at different times introduced into the arm pieces of bone, broken very small, taken from the tibia of children, in order to rectify incurvations. As a result of these proceedings, the engrafted pieces of bone grew, and in course of fourteen months from the time of the first transplantation, the boy had a functional humerus; its general appearance is depicted in Fig. 54.

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[*] "Archiv für Klin. Chir.," vols. xxxv. and xxxvi.

[†] Weir Mitchell: "Injury of Nerves," p. 47.

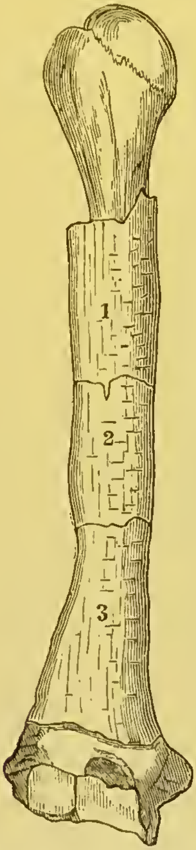

Fig. 54.—A Humerus reformed by Transplantation of Bone in a Boy. The figures 1, 2, 3 represent the segments of bone restored at each operation. (After Macewen.)

In the drawing the figures refer to the segments of the new humeral shaft, which were reproduced from the osseous fragments introduced in the three operations.

Dr. C. W. Trueheart,* of Texas, has recently reported a case in which the central portion of the clavicle was destroyed by a gunshot wound. The patient was much disabled by the lack of support to the shoulder. The cicatrix was cut out, leaving a wound three-quarters of an inch deep, one inch wide, and two and three-quarters inches long between the ends of the bone. After a bed of granulations had formed upon the surface, it was covered with periosteal and thin bony grafts, of the size of hemp seeds, taken from the limbs and scapulæ of dogs. Three graftings of ten pieces each were done at intervals. In two months the gap appeared filled with a firm tissue of bony consistence.

Surgeons have conducted some experiments in transplanting portions of corneal tissue from the eyes of rabbits and dogs in order to remedy dense opacities of the corneæ in man. Although in some instances the proceedings were successful in so far as the vitality of the transplanted tissue was concerned, yet in a very short time it became opaque, which nullified any benefit likely to accrue to the patient from the operation.

Some attempts have recently been made, in cases of enucleation of the eyeball for disease in the human subject, to transplant the eyeball of dogs or rabbits.†

There is a variety of transplantation which may for convenience be termed *transposition*. Such cases as those in which a flap of skin is turned down from the forehead to form a new nose, or those which are used to rectify extroversion of the bladder, are examples. In this way, Nussbaum, with saw and chisel, transposed, in a case of ununited fracture of the ulna, a portion of bone from the upper fragment into the gap, and with success.

In the case of a cat, I succeeded in transposing the median and ulnar nerves. The two nerves were divided about the middle of the arm; the proximal end of the median was united to the distal end of the ulnar, and *vice versâ* (Fig. 55). Union occurred; sensation and motion returned in six weeks. The cat regained complete use of the limb, and did not appear to suffer any inconvenience. She was killed nine months after the operation.

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* "Internat. Jour. Med. Sci.," vol. i., p. 290.

† *Ibid.*, vol. i., p. 286.

From cases of designed transplantation we must now pass to consider other examples not so deliberate.

In the museum of the Royal College of Surgeons is a portion of the trachea of a dog with some small spiculated warty growths near its bifurcation. The head of this dog is preserved in the same collection. The mucous membrane of the mouth and tongue are thickly beset with papillomata, and it seems probable that some wart-germs were carried down the trachea from the fauces, and grew as transplanted tissue.

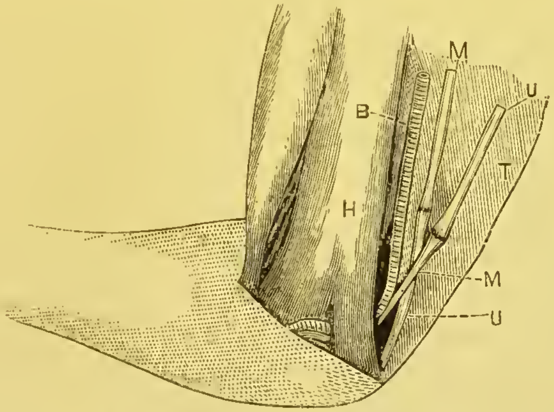

FIG. 55.—FOREARM OF CAT.

The ulnar nerve has been experimentally united to the median, and the median to the ulnar.

H, humerus. B, brachial artery. M, median. U, ulnar nerve.

In the case of a boy who died in the Middlesex Hospital from sarcoma affecting the kidney, a portion of the new growth ulcerated into the renal vein, and small fragments of sarcomatous tissue were carried into the lungs, where they became arrested by the pulmonary capillaries, and formed new foci of disease to such an extent that the lungs contained great numbers of these tumours, varying in size from a pea to a walnut. Specimens of this mode of transplantation are far from rare. Some forms of ovarian cysts furnish striking instances of the transplantation of morbid tissue. In those cysts which occur in the immediate neighbourhood of the ovary, probably having their origin in remains of the mesonephros, the interior is often found covered with papillomata; hence they are termed papillary. In a few recorded cases these cysts have been known to rupture, and their contents spread throughout the peritoneal cavity. In some instances portions of the papillomata have engrafted themselves on to the peritoneum, and formed independent warts.*

Interesting instances of accidental transplantation of tissues which may eventually become a tumour, are those cases of so-called sebaceous cysts of the fingers which have followed injury. Thus in one case a man pricked his finger with a piece of steel in the flexure of the joint; a small nodule appeared at the injured spot, which was removed, and found to consist of densely-packed epithelial scales. In another case a woman pricked herself with a sewing needle, and a like result followed. In all cases of these cysts there seems to be a history of antecedent injury. This goes to show that at the time of the accident small particles of the skin or epidermis are carried into the tissues by the instrument by which the wound is inflicted, and behaving as grafts, become the starting-point of tumours.†

Among the most of these cases must be mentioned iritic cysts. Cysts of the iris are of comparative rarity, and generally appear as transparent vesicles situated on its anterior surface. As a rule, they are more or less sessile, but may possess a pedicle. The contents may be opaque, and, in certain exceptional cases, have been found to contain the same kind of material as sebaceous and dermoid cystomata. Mr. Hulke,‡ in a valuable paper "On Cases of Cysts in the Iris," has collected some valuable material dealing with the origin of these structures, and indicates that in fifteen out of nineteen cases, as well as in two reported by himself, there was a distinct history of foregoing mechanical injury. This suggested to him the idea that in some instances, perhaps, the cyst may have originated from a portion of Descemet's membrane, which may have been torn from the back of the cornea by the penetrating body, and carried into the iris.

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* Knowsley Thornton: "Path. Soc. Trans.," vol. xxviii.

† Poland: "Path. Soc. Trans.," vol. xxxv., p. 399. Bowley: *Ibid.* Davies-Colley: *Ibid.*

‡ "Royal Lond. Ophth. Hosp. Rep.," vol. vi., 1869.

Rothmund believes that dermoid cysts of the iris probably owe their origin to the implantation of a portion of the cutis or hair bulb which has occurred during some traumatic lesion of the eye. The other varieties of iritic cysts, he holds, are due to proliferation of implanted cells of the conjunctival covering of the cornea.

The museum of the College of Surgeons possesses the following specimen :—

"The eyes of an albino rabbit, with the cornea removed to expose a portion of transplanted cartilage adhering to each iris. Minute portions of the intermediary cartilage from the femur of a young kitten were inserted into the anterior chambers. They became adherent to the iris, partially vascularized, and grew to about eight or ten times their original size; but subsequently absorption commenced, and they were reduced to their original size when the animal died."

This specimen shows that transplanted tissue will grow when attached to the iris; on this head we have the accumulated observations of several experimenters, Dooremaal, Goldzieher, Schweninger, Zahn, and Masse, who introduced various kinds of tissue, such as cartilage, hairs, and conjunctiva, into the anterior chambers of rabbits; and in very many instances such transplanted tissue grew. In some of the cases such tissues were absorbed, and others were extruded from the eye. The latest contribution to this subject is by Hosch, who, in a paper on "Experimentelle Studien über Iriscysten,"* gives a brief account of previous investigations (but has evidently overlooked Mr. Hulke's paper), and corroborates them by some additional experiments performed on the eyes of rabbits.

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* "Virchow's Archiv," Bd. cxix., S. 449.

The accompanying drawing (Fig. 56) represents a portion of conjunctiva attached to the iris in one of these experiments. These investigations powerfully support the view that iritic cysts may have origin in epithelial rudiments engrafted on the iris as a result of accident.

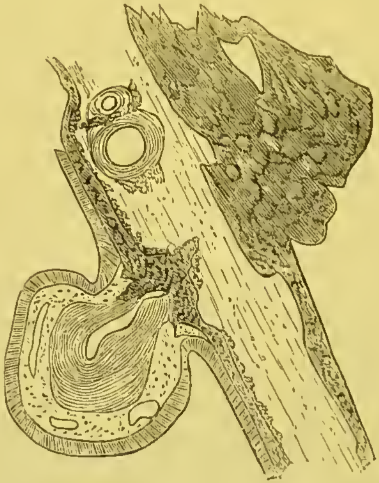

Fig. 56.—Section through the Iris of a Rabbit, on which a piece of conjunctiva was implanted. (After Hosch.)

Weir Mitchell* relates an interesting example of transplantation which was observed by Verneuil:—

"A gunshot wound broke the elbow, and, after resection, amputation became necessary at the close of a month. On examining the radial nerve (*Ang.* musculo-spiral nerve) a little above the bend of the elbow, it was found inflamed and swollen, and on one side of the enlargement, and penetrating it, was seen an irregular bony mass of the size of a bean, of recent colour and feeble consistence."

As this was not a piece of old bone, it was probably due, as M. Verneuil believed, to a piece of accidentally transplanted periosteum, which had given rise to a certain amount of ossification at a point quite remote from the callus.

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* "Injuries of Nerves," 1872, p. 119.

SECTION III.

LEEDS & WEST-RIDING
MEDICO-CHIRURGICAL SOCIETY

CHAPTER XI.

CYSTOMATA.

Definition.—*A true cyst is the result of an abnormal dilatation of a pre-existing tubule or cavity.*

The walls are usually composed of fibrous tissue, but may be made up of more complex structures. The contents are always distinguishable from the envelope, the interior of which may be lined with endothelium or epithelium.

Cysts may arise in a variety of ways, but *true* cysts originate in one of the following:—

(1) The dilatation may result from the retention of the normal secretion of the part owing to the closure of the excretory duct or ducts—retention cysts.

(2) By increased exudation into a cavity which is unprovided with an excretory duct—exudation cysts.

(3) The dilatation may affect functionless ducts and tubules (examples of which are always present in the body), or tubules rendered functionless by disease—tubulo-cysts.

The contents of cysts are very various, and serve as a basis of classification in the same way that the varieties of tumours are distinguished by their structure. Thus may we find in these abnormal cavities, serum, milk, sebum, cholesterine, colloid material, saliva, etc.

Secondary changes may affect the cyst-wall or its contents. The cyst-wall may become the seat of new growths, producing secondary cysts, villous or papillary processes, hair, glandular and other structures.

They may inflame, suppurate, and become filled with pus or blood, or granulate and suffer obliteration.

Calcification of the walls may occur, or the contents may become inspissated, and later, form a nidus for the deposition of calcareous particles. The epithelial elements may undergo fatty changes, and flakes of cholesterine are frequently found among the contents of the cyst.

CLASSIFICATION OF THE CYSTOMATA.

I. RETENTION CYSTS.

1. Sebaceous
2. Mucous
3. Ranula
4. Pancreatic Ranula
5. Galactocele
6. Biliary
7. Hydronephrosis
8. Hydrosalpinx, etc.
9. Pyometra

II. EXUDATION CYSTS.

1. Bursa
2. Ganglion
3. Ovarian
4. Hydrocele and Hæmatocele
5. Simple Broad Ligament

III. TUBULO-CYSTS.

1. Parovarian
2. Papillary
3. Vaginal (in connection with Gartner's ducts)
4. Oviducal
5. Allantoic
6. Meningocele
7. Spina Bifida
8. Sacral
9. Branchial
10. Renal

For many reasons it would be very convenient to follow the order of the above table in describing the different forms of cysts, and although as far as possible this plan will be adhered to, nevertheless it will be found necessary, for the sake of clearness, to deal with cysts arising in the reproductive organs in a group by themselves; not that they present any features in their mode of origin, growth, or behaviour in any way different from cystic structures in general, but inasmuch as they constitute a very important group to the practical physician and surgeon.

The consideration of dermoid cysts, sacral hygromata, and branchial cysts has such a special bearing on the subject of the etiology of new growths, that they will be dealt with in a separate chapter.

RETENTION CYSTS.

(1) *Sebaceous Cysts.*—These are formed by the retention of secretions in the sebaceous glands; they occur in all situations where these glands normally exist, but in man are most frequent on the scalp, in which situation they are often termed wens.

These cysts may vary in size from a pin's head to that of a small orange. Their walls may be thin and pliant, or laminated, thick, and hard: in the first condition they are composed of thin connective tissue; in the second case they may be formed of tough fibrous tissue. Occasionally they may be calcified; but this is rare. The inner surface of the wall is clothed with epithelium, which may be shed in successive layers into the cyst, giving it a laminated appearance. In some rare instances warts may develop on the inner layer. The contents of sebaceous cysts are most commonly epithelial scales, granular fatty matter, and flakes of cholesterine.

Although in man sebaceous cysts are far more common on the scalp, where indeed they are often multiple, than in any other situation, nevertheless they may be found on the back, and even in the perinæum, where a cyst of this kind has been known to attain the dimensions of a small orange. Among other curious places, sebaceous cysts have been found deeply situated in the tissues of the neck; their occurrence in this apparently anomalous situation is explained by the temporary existence in the neck, in early embryonic life, of the branchial clefts.

Sebaceous cysts in the external auditory meatus occur occasionally in the human subject, and may lead to disastrous results. Mr. Toynbee published an account of a series of such cases,* and states that they are found chiefly at the innermost part of the meatus, close to the membrana tympani; they vary in size from a millet-seed to a large nut, and produce by their pressure enormous distension of the meatus, and absorption of the petrous bone to such an extent as to open up a communication with the mastoid cells and even the cranial cavity.

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* "Med.-Chir. Soc. Trans.," vols. xliv. and xlvii.

Cysts resembling the sebaceous variety have been found on the iris and on the tips of the fingers; but these cases are nearly always, if not always, associated with antecedent injury (*vide* for explanation page 156).

They also occur on the eyelids, especially of children, where they are known as molluscum. Sebaceous cysts are by no means confined to man, for they have been described in horses, dogs, and birds; the latter seem to be especially liable to them.

Dr. Thin has given a description of some sebaceous cysts which occurred in horses ("Path. Soc. Trans.," vol. xxx., p. 588). The museum of the Royal College of Surgeons, London, possesses specimens taken from the head of a partridge, neck of a fowl, the wings and legs of wood-pigeons; and one interesting specimen from the head of a bird is represented in the accompanying drawing (Fig. 57). It has grown in connection with the upper eyelid, and well illustrates the laminated arrangement the contents of these cysts very frequently assume.

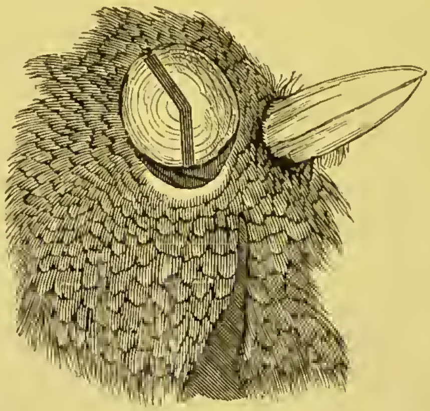

FIG. 57.—HEAD OF A BIRD WITH A SEBACEOUS CYST GROWING IMMEDIATELY ABOVE THE EYE.

It is cut so as to show the laminated arrangement of its contents.

A curious condition sometimes found associated with sebaceous cysts in the human subject is a cutaneous horn. They may arise either from the interior of an unruptured cyst, and, bursting the cyst-wall, may continue their growth, or they may sprout from the wall of a cyst already ruptured. In structure they are composed of epidermal cells, but the outer layers, on account of exposure to the air, are dry and horn-like both in appearance and consistence.

The most elaborate collection of cases illustrating this singular condition is to be found in a small work by Dr. Hermann Lebert, entitled "Ueber Keratose oder die durch Bildung von Hornsubstanz erzeugten Krankheiten" (Breslau, 1864). This writer gives an account of no less than one hundred and nine cases, with full references, the earliest dating from the year 1300. The horns were found on the scalp, temples, forehead, eyelids, nose, lips, cheeks, shoulders, arm, elbow, thighs, legs, knee, toes, axilla, thorax, buttock, loin, penis, and scrotum. In length they varied from a fraction of an inch to as much as ten or twelve inches, and in circumference some of them measured eight inches. The majority of these cutaneous horns occurred on the head.

Cutaneous horns of this character are associated with sebaceous cysts in mammals and birds.

Everard Home, in 1791, contributed an interesting paper to the "Phil. Trans.," entitled "Observations on Certain Horny Excrescences of the Human Body." After referring to numerous well-marked and extraordinary cases of horny growths occurring in human beings, he describes the following case in a footnote :—

A sheep, about four years old, had a large horn, three feet long, growing on its flank. It had no connection with bone, and appeared only to be attached to the external skin. It dropped off in consequence of its weight having produced ulceration of the soft parts to which it adhered. On examining it there was found a fleshy substance, several inches long, of a fibrous texture, filling up its cavity, on which the horn had been formed.

Hunter was well aware that these horns are nothing more than cuticular productions arising from a cyst:. and Home refers to a case in which one grew from the tip of a sheep's ear; he shows the analogy these spurious horns bear to the horn of the rhinoceros thus:—"The horn of the rhinoceros is a cuticular appendage, similar to nails and other cuticular excrescences, being in no respect allied to horns but in the external appearance."

The book by Hermann Lebert, before mentioned, contains instances of cutaneous horns in animals. Malpighi described one growing from the neck of an ox; it was in length equal to ten, and at the base equal to eight fingerbreadths. Also from sheep, he-goats, the nose of a ram, horses, a hare, cows, dogs, from the neck of an old hen, the head of a parrot, and in one case on a greenfinch.

It has been mentioned that sebaceous cysts are found in the external auditory meatus, and the head of a cock, with one of these horny growths sprouting from the external auditory meatus, is preserved in the museum of the Royal College of Surgeons, London. In the same collection there is a mule canary (cross between a linnet and a canary) with a sebaceous cyst on the left wing. From this cyst there sprouted a horny growth, which, when removed, recurred each year for five years.

These cases are valuable, for they show incontestably that the same kind of cyst occurs in birds, animals, and man, and may give rise to similar secondary productions—"horns." I shall now proceed to show that in at least one instance this variety of horn is inherited, so as to become a race character.

On the inner side of the fore leg of the horse may be seen a horny production, cuticular in origin, unconnected with bone, and presenting all the characters of horn. The general appearance of this curious structure must be familiar to everyone; it is known as the "castor." It varies a great deal in size; I have seen it as long as six inches, but ordinarily it projects about an inch above the level of the surrounding skin. If removed it grows again. It is wanting in the ass; but in the corresponding part of the fore leg there is a hairless black patch usually to be found. These castors have always excited my curiosity; they are so constant, yet so useless, that, seeing they agree in structure with the cuticular horns of men, there is only one way out of the difficulty—they are inherited pathological productions.

Admitting, then, that cuticular horns in men, or on the wings of birds, in the ear of the cock, on the side and pinna of a sheep, and the castors of the horse, are pathological, there is no valid reason why the horn or horns of the rhinoceros may not be regarded as arising as pathological productions in the first place, but being utilized by the animal, have been retained and transmitted.

With regard to the "castors" of the horse, it may be well to mention that their symmetry is no objection to the view of their pathological origin, for it is well known that diseased productions are very frequently symmetrical.

Cutaneous Piliferous Cysts.—Closely allied to sebaceous cysts is a variety usually relegated to that comprehensive class known as dermoid cysts. Of the class to which the name cutaneous piliferous cyst should be applied, we may choose as the type the small congenital cysts so frequently found at the outer angle of the orbits in children. In well-marked examples the cyst-wall is composed of tissues indistinguishable from skin, and enclosing sebaceous material mixed with cholesterine. Sprouting from the wall, and projecting into the cavity of the cysts, are hairs, which may vary from a few fine hairs growing from the wall and resembling lanugo, or the interior may contain a considerable coil of this material rolled into a ball.

The difference between these cysts and the sebaceous variety depends on the circumstances that they contain hair, are always congenital, and their walls are composed of skin; but sebaceous cysts are more or less cutaneous in structure, develop dermal organs—horns—and when burst and exposed to the air, their lining membrane becomes indistinguishable from the surrounding skin, and though not congenital they are nevertheless distinctly hereditary.

The intimate relation existing between the development of hair and sebaceous glands from the same down-growth or diverticulum of the epidermis forbids the separation of the two varieties. It is easy to trace every gradation from the sebaceous cyst due to retention of the secretion, to forms arising from developmental errors which may produce a sebaceous cyst *without* a duct or minute orifice, or a piliferous cyst.

It may be, as Sir James Paget well expresses it,—"perhaps only during the vigour of the formative forces in the fœtal or earliest extra-uterine periods of life, that cysts thus highly organized and productive are ever formed."

The examination of many of these tumours convinces me that this variety must be separated from that group of tumours known as dermoid or teratoid, and they are simply a highly-organized variety of sebaceous cysts. Such cysts occur in animals, and the museum of the Royal College of Surgeons, London, possesses some exquisite examples from sheep and oxen, removed from beneath the integument, and containing hair or wool alike in characters and colour with that growing on the skin of the animals from whom the cysts were removed.

Similar cysts have been found beneath the skull-cap, lying on the dura mater. Such a case has been described by Professor Turner in the "St. Bartholomew's Hospital Reports," vol. ii., p. 62. It was in a child aged twenty-three months, and lay beside the torcular Herophili, within the layers of the dura mater. It contained hair, and was unassociated with any defect in the occipital bone. Sir James Paget described a case which occurred in an old man; the cyst lay in the tissue of the pia mater under the cerebellum ("Surgical Pathology").

Dr. Ogle published a case in the "Brit. and For. Med.-Chir. Review," 1865, where, in a child two and a half years old, one of these cysts was found within the layers of the dura mater close to the junction of the superior longitudinal sinus with the torcular. This was associated with a defect in the supra-spinous portion of the occipital bone.

These cases receive a satisfactory explanation if we take into consideration the development of the skull. Morphologically regarded, the bony framework of the skull is an additional element to the primitive cranium, which is really represented by the dura mater. Strictly, the term extra-cranial should apply to all structures outside the dura mater. As a matter of fact, in early embryonic life the skin and dura mater are in contact. This relation later becomes disturbed by the intervention of the cranial bones. If an aberration of the skin occurs before the advent of ossification, it may be pushed towards the dura mater, or the skin, or retain, by means of a pedicle, its old attachment to the latter, whilst the bulk of the cyst lies on the inner side of the bone.

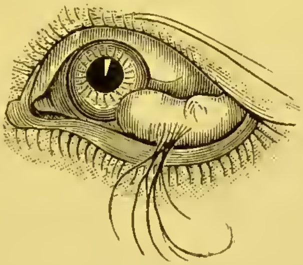

FIG. 58.—CUTANEOUS PILIFEROUS GROWTH ON THE EYE.

The following cases are of some interest in their relation to detached germs of skin.

Wardrop ("Morbid Anatomy of the Human Eye," 1834) mentions a curious case which occurred in a man who was at the time fifty years old. The growth, which had been observed from birth, was situated on the white of the eye, next the temporal angle of the orbit. Twelve very long and strong hairs grew from its middle, passed between the eyelids, and hung over the cheek. The patient stated that these hairs did not appear until his sixteenth year, when the beard began to grow (Fig. 58). Similar cases have been observed by other surgeons.

The following instances show that such growths are not confined to human beings:—

In a case recently reported,* in a two-year-old bullock, a similar growth occurred on the cornea. It was in size about the circumference of a shilling, and a quarter of an inch in thickness, with a tuft of silky hair, an inch in length, growing from its centre.

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* "Veterinary Journal," vol. xxi., p. 235.

Dr. Dobson[*] published an account of one which grew on the eyeball of a mongrel bull-terrier.

The patch of integument was triangular in outline, with its base corresponding to the outer margin of the cornea, and the apex towards the outer canthus. The skin was clothed with hair exactly like that on the dog's back. The abnormal patch looked as though a piece of skin had been taken from the animal's back and grafted on the eyeball. The dog was full-grown, but the testes were not in the scrotum.

In 1870 a sheep's eyeball was sent to the College of Surgeons, London, for preservation in the museum, which presents a similar condition. It is thus described by Dr. Garson[†] :—"The preparation shows at the outer canthus and superiorly a projection resembling a mole; it is of rounded form, measuring about five millimetres in diameter, situated along the edge of the cornea. From the top of this springs a lock of wool, some of the fibres of which are as long as 6 cm. The growth is of a brown colour, more deeply pigmented at some points than at others, so that it presents a mottled appearance."

The following case[‡] occurred in a greyhound puppy aged three months:—On the ball of each eye, at the outer corner, there is a quantity of hair, which entirely covers the white of that part, and approaches quite up to the pupil.

M. Cagny[§] has recorded, under the name of "pterygion dermoïde double," an example of these growths—a small tumour, furnished with hairs and covering a portion of the sclerotic of each eye, occurred in a dog aged three months. The abnormal patches prevented the proper closure of the eyelids, and hindered vision. The shape of the growth was that of a triangle with the base towards the temporal side of the orbit, and the apex towards the cornea. The hairs covering it resembled those on other parts of the animal.

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[*] "Journal of Anatomy and Physiology," vol. xiv., p. 143.

[†] *Ibid.*, vol. xiv., p. 252.

[‡] "Veterinarian," vol. xxvi., p. 777.

[§] "Rec. de Méd. Vét.," Juin 30, 1885, p. 218.

Mucoid Cysts.—These arise from retention of secretions in the glands of mucous membranes, and bear the same relation to these membranes that sebaceous glands do to the skin. The best examples of mucous cysts are those in connection with the mucous glands of the cervix uteri, and are known as Nabothian cysts. Others arise in connection with Bartholin's glands in the vagina, or Cowper's glands in the male. Mucous glands are regarded as the origin of certain cysts which occur in the antrum,[*] in the stomach,[†] on the epiglottis,[‡] the lining membrane of the trachea and œsophagus. These cysts vary in size, but as a rule they are small; they contain generally a colourless, opaline, ropy fluid, but the contents may be of an inky colour. Mucous cysts are liable to suppurate, and calcification may affect their walls, especially when they appear on the lips.

Ranulæ.—These are cysts which usually arise from obstruction to the ducts of the salivary glands, often from the impaction of a calculus. Some forms of ranula are probably due to enlargement of mucous glands (mucous cysts) in the immediate neighbourhood of salivary glands. Recklinghausen[§] has drawn attention to the occurrence of ranulæ in connection with a mucous gland situated at the tip of the tongue, described by Nuhn and Blandin. Sonnenberg[||] has recently confirmed Recklinghausen's views. The term ranula is usually reserved for those forms of salivary cysts which occur in connection with the submaxillary and sublingual glands, but they may happen also in connection with the parotid gland.

Ranulæ have been found in horses and cows, where they may attain a large size in connection with the duct of the parotid and sublingual glands in these animals. It is interesting to note that certain animals with large submaxillary glands develop a salivary bladder in connection with the duct of this gland, *e.g.*, the armadillos.

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[*] Giraldès: "Recherches sur les Kystes," Paris, 1860.

[†] "Virchow's Archiv," xlvii., p. 1.

[‡] Durham: "Med. and Chir. Soc. Trans.," vol. xlvii., p. 7.

[§] "Virchow's Archiv," vol. lxxxiv., p. 425, 1881.

[||] "Arch. Klin. Chir.," vol. xix., p. 627, 1883.

Pancreatic Ranulæ.—It is so common to refer to ranulæ in connection with the submaxillary gland, that many writers overlook the fact that they also occur in connection with the parotid gland. Virchow draws particular attention to this matter in his celebrated work on "Tumours," and further shows that the pancreas may be similarly affected.

The duct of this gland is liable to be obstructed from many causes, calculi, biliary or pancreatic, tumours in the immediate neighbourhood, and cancer of the bile papilla. As a result of such obstruction, the duct may dilate immediately behind the orifice, and form a large cyst; or a series of ectasia may arise and give the gland the form of a chaplet of cysts. In some cases these cysts attain the size of an orange, and if involving the whole of the pancreas the gland may attain the thickness of a wrist. The contents of the cyst may be the normal secretion of the gland, mucus, or even coagulated blood. The most elaborate inquiry into this question of pancreatic cysts is that published by G. W. Johnson,* "On Calculous and other Affections of the Pancreatic Ducts."

This author mentions that in cases of obstruction of the main duct, cysts may be formed measuring, in some cases, three or four inches; in others they may be as large as a child's head. In early cases the contents of the cysts are simply the retained secretion of the gland, but secondary changes arise as the case progresses, leading to fibrous thickening of the cyst-walls, which may even become ossified (calcified!). The contents of the cyst undergo changes, becoming mixed with cholesterine, purulent matter, blood, etc. The cysts may attain sufficient size to become a source of danger by pressing on surrounding structures.

Galactoceles.—These cysts are local dilatations of the ducts of the mammary gland. They are best marked in the female during lactation, and arise as uniform dilatations of the galactophorous ducts. In the first stages of their formation they contain milk; but later this may undergo absorption, and simple serous fluid remain. At times, however, a substance, having the characters of casein, replaces the milk. Birkett states that the walls of galactoceles may at times calcify.

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* "American Journal of Medical Sciences," 1883, p. 404.

The term galactocele is sometimes applied to swellings caused by the rupture of the galactophorous ducts, followed by the extravasation of milk into the tissue; but these cases ought not to be termed cysts—the name should be confined to actual ectasia of the excretory ducts themselves.

Biliary Cysts.—If from any cause, such as inflammation, morbid growths, calculi, parasites, or congenital absence of the common duct, etc., the bile-ducts are obstructed, dilatation of the ducts behind the occluded portion follows. If the common duct be obstructed, the gall-bladder becomes, in course of time, thin and dilated from an accumulation of serum within, and becomes a veritable cyst. Should the obstruction continue, the ductus communis choledochus and larger bile-ducts will dilate, and in some extreme cases may increase in size to tubes half an inch in diameter, admitting the finger with ease.

In cases of atrophy of the liver-tissue from any cause, portions of the biliary passages are cut off by the contracting tissue from communication with the surrounding ducts; the result is, that in many cases the confined portion of the duct has no outlet for the secretion which is passed into it, and dilates in consequence. In this way numerous cysts arise in the liver. Such cysts are of various sizes, but rarely attain greater dimensions than a nut or cherry. Their walls are generally thin and slimy. If of recent formation, the contents are usually brown or of a dirty green colour; if old, they are filled with clear limpid fluid. Biliary calculi are frequently found in them. Occasionally they contain colloid material.

Recklinghausen* is of opinion that the cysts often found beneath the capsule of the liver arise in this manner. In the "Path. Soc. Trans.," vol. xxxiii., p. 168, Dr. Sharkey reported a hepatic cyst of this kind as large as the head of a new-born child. Large cysts of this nature are very uncommon.

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* "Virchow's Archiv," vol. lxxxiv.

In some rare instances the common bile-duct fails to communicate with the gut, and ends in a cul-de-sac. In one example dissected by me, which occurred in a young antelope, the common duct had failed to enter the duodenum; the ducts which ramified through the hepatic tissue were enormously dilated, so that the organ resembled a sponge honeycombed by biliary passages; in many parts of their course they were sufficiently dilated to admit the finger easily. The animal was five months old, and it is curious that no signs of jaundice had been observed, or were even observable in the carcase at death, although there was every reason to suppose that the defect was congenital in origin.

*Hydronephrosis.**—If from any cause a permanent impediment to the flow of urine occur, serious changes arise in the kidney, often leading to its total destruction, and even to the death of the individual to whom the kidney belongs.

The obstruction to the free flow of urine may arise in a variety of ways—calculus lodged in the urinary passages, or affections of the walls themselves, or pressure on the ureter from without. The first result of obstruction to the free flow of urine is an accumulation of fluid behind the obstructed part, leading to dilatation of the pelvis of the kidney and infundibula; this occasions pressure on the renal substance, and, as a consequence, the true secreting tissue of the kidney becomes thinned, atrophied, and often an enormously dilated ureter in connection with a large cyst, the walls of which are composed in part of a thin layer of renal tissue, is all that remains.

Hydronephrosis is often congenital, and several cases have been recorded in new-born babes. In some of these cases the ureters are so dilated as to admit easily the little finger.

The accompanying drawing is from a case which occurred in an Argus pheasant, in which the dilatation has brought almost complete destruction of the affected organ (Fig. 59).

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* For an admirable account of Hydronephrosis and Cystic Kidney, consult Morris, "The Surgery of the Kidney," 1886.

It is in this way that the majority of cases of single kidney, especially those known as single unsymmetrical kidney of Rokitansky, are produced, viz., atrophy of the renal substance in consequence of the pressure of the retained fluid, and subsequent contraction of the cyst.

The museum of the Royal College of Surgeons possesses a beautiful example of hydronephrosis in a dog due to obstruction of the ureter by vesical calculi.

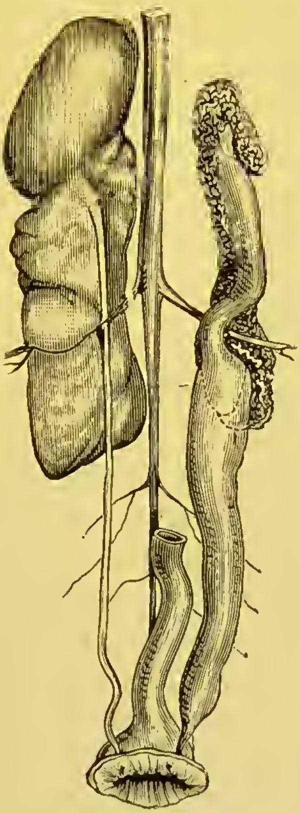

FIG. 59.—KIDNEY OF ARGUS PHEASANT.

Ureter dilated in consequence of obstruction ; sacculation and loss of kidney.

The condition occurs in horses, asses, cows, pigs, and other domestic animals, as well as in birds.

Hydronephrosis must be regarded as cystic distension of the pelvis of the kidney due to accumulation of its contents; it is therefore an example of a retention cyst, the atrophy of the renal substance being the direct result of pressure exerted by the enlarging cyst. Although in the majority of cases the whole kidney is affected, yet if the obstruction be limited to an infundibulum, the sacculation will affect only that part of the renal tissue drained by the infundibulum.

Renal Cysts.—These are of two kinds, excluding those examples classed as hydronephrosis or sacculated kidney—(1) the cystic kidneys associated with interstitial nephritis: (2) the congenital form of cystic kidney.

The first form, or cysts associated with chronic disease of the renal organs, are exceedingly frequent, and may be of various sizes, and present themselves in greater or less abundance in the secreting substance, but more especially in the cortical substance. In size they may be microscopic; very frequently they equal a pea in dimensions, and occasionally they attain the size of a walnut; rarely are they larger than this. Their contents are usually colloid material. The cysts arise either by degeneration and subsequent dilatation of the Malpighian bodies, which have become cut off from the tubules in consequence of the changes in the interstitial tissues, or in the gradual distension of portions of uriniferous tubules, detached from the main tubules in consequence of partial obliteration, the result of excessive formation of the intertubular connective tissue characteristic of the chronic form of interstitial nephritis.

Although cysts arising in this way are of frequent occurrence in the human subject, nevertheless they are very rarely found in animals—indeed the only reliable cases known have been found in the horse and cow. In these instances the changes in the kidneys were the residue of an attack of acute nephritis.

The chief predisposing causes of chronic interstitial nephritis, viz., alcoholism and gout, are affections probably wholly human; lead-poisoning is a recognized affection in horses.

(2) *Congenital Cystic Kidneys.*—In this form the main facts are these:—Both kidneys are affected; the organs are larger than usual, sometimes so large as to cause serious

impediment to delivery, not only in the human subject, but also in cows, sheep, and pigs.

The kidneys may be malformed, *e.g.*, horseshoe kidney; and in nearly all cases the pelvis of the organs is wanting, being often replaced by fatty tissue. The ureter is exceedingly thin, but in most cases pervious, and the renal arteries excessively attenuated.

The individual possessing such kidneys is nearly always malformed, presenting such conditions as club-foot, anencephalia, spina bifida, etc. In most cases the peritoneum in relation with the kidneys is very thick, and shows signs of inflammation, such as strong bands of adhesions passing from them to the testicles, ovaries, liver, spleen, or portions of the intestines. In all cases examined by me (ten in number) the abdomen contained peritoneal fluid.

The kidney is made up of a congeries of cysts, giving to it a sponge-like appearance on section, but externally it preserves its lobulation. The cysts vary much in size; they may be as small as a pea or as large as a nut. The cortical and medullary portions are, as a rule, indistinguishably blended, but sometimes small tracts of cortical substance are seen.

In the early stages the walls of the cysts are composed of a membrana propria, and coated internally by a layer of tesselated epithelium, in some instances of extreme beauty.

Up to the present time it has been customary for pathologists, following the opinion of Virchow, to regard these cystic kidneys as examples of ectasia of the uriniferous tubules in consequence of the absence of a pelvis to the kidney. The recent researches of Mr. S. G. Shattock put the matter in a new aspect, for he shows that in these cases we have to deal with a combination of mesonephros (Wolffian body) and metanephros (true kidney). For instance, if sections of the trunk of a human fœtus be made at about the sixth week of intra-uterine life, when the mesonephros is fully developed, it will be found that the microscopical appearances of the congenital cystic kidney correspond with those of the mesonephros. Not only have I satisfied myself that this is so in Shattock's specimens, but I have had ample opportunities of verifying the condition in several specimens contained in the museum of the Middlesex Hospital.

Besides the evidence afforded by the cystic kidneys, valuable information is afforded by the microscopical examination of the paroophoron.

Under certain conditions, especially in the malformation known as anencephalia, this appendage of the ovary is very large. All embryologists agree that this structure is really the remains of the mesonephros. Careful examination and comparison of sections from an unusually large epoophoron, a mesonephros, and a congenital cystic kidney present an identity of structure which is unmistakable. The same holds good for the paradidymis (see page 221).

These observations go to show that in the curious congenital cystic kidney, which must be distinguished from congenital hydronephrosis, we really have to deal with a more or less persistent mesonephros associated in a greater or lesser degree with normal renal tissue.

Most of the London pathological museums possess one or more examples of this condition. The Middlesex Hospital Museum contains no less than four specimens. The Hunterian Museum possesses a beautiful example in the kidney of a sheep—indeed it is the most perfect I know of. It is simply described in the catalogue as "a sheep's kidney, the whole substance of which is replaced by numerous thin-walled cysts."

The museum of the Royal Veterinary College possesses a good example, which is probably that of a sheep, and I have examined a similar specimen in the museum of the great Veterinary School at Alfort.

Kidneys similarly affected, and causing obstruction to labour, have been recorded as occurring in calves.

Cysts of the Vermiform Appendix.—It frequently happens that foreign bodies lodge in the vermiform appendix, or inflammation from other causes occludes the narrow opening by which this tube communicates with the cæcum. One of the consequences of the closure of the orifice is distension from serous exudation into the appendix, which enlarges and assumes all the characters of a cyst, sometimes attaining considerable dimensions (Fig. 60). The contents may be serum or mucus, and in some cases pus. The cystic dilatation of the vermiform appendix is a source of real danger, for rupture may take place, giving rise to fatal peritonitis.

Such a condition can only occur in man and the anthropomorphous apes; no other animal possesses a distinct appendix to the cæcum.

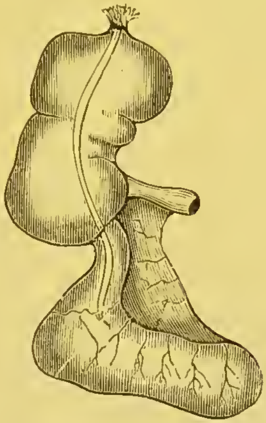

FIG. 60.—A DILATED VERMIFORM APPENDIX.

Vitelline Duct.—During the whole period of development in fish, birds, and reptiles, the embryo obtains its nourishment from the yolk contained in the yolk sac, the pedicle of which is known as the vitelline duct. In mammals the fœtus depends only for a brief space on the yolk; the umbilical vesicle (yolk sac) and vitelline duct remain merely in a rudimentary state, but occasionally they grow *pari passu* with the fœtus, and are often to be detected as a diverticulum or as a cyst connected with the lower portion of the ileum, and of the same capacity as the bowel.

Under these conditions the duct may mechanically become a source of danger to the animal, for if it be attached, as these ducts often are, to the umbilicus, a coil of bowel may get thrown over it, and fatal strangulation result.

Allantoic Cysts.—In man, in common with many other mammals, it is customary for the urachus to become completely impervious from the place where it leaves the bladder to the umbilicus; but it occasionally happens that the urachus may become dilated and form a cyst, or if unequally distended, a series of cysts, as shown in Fig. 61.

A very complete account of allantoic cysts is furnished by J. B. Wutz, in a paper published in "Virchow's Archiv," Bd. xcii., entitled "Ueber Urachus und Urachuscysten." Besides collecting recorded instances of the occurrence of these cysts in man, he quotes cases from Meckel, Gurlt, and Hoffmann identifying the existence of similar cysts in animals.

In Meckel's case,* the subject was a fœtal pig (*einen reifen Schweinsfötus*). The urachus, about four inches from the navel, presented a dilatation an inch wide and the same in length.

Gurlt† gives an account of two cases, one in a horse, the other in a cow. It seemed as though there were two bladders communicating with each other.

Hoffmann's‡ example occurred in a pig. It presented the appearance of a double bladder, the lower division of which measured 31cm. in length, and 22cm. in width. The upper one was 25cm. long, and 24cm. wide; the two compartments were in relation by a tubular portion 9cm. in diameter. I have seen a very good example of an allantoic cyst in a mole.

An early stage of a single allantoic cyst is presented in Fig. 61, taken from a fœtus. Critical examination of some museum specimens of sacculated bladders goes to support the opinion that some of these cysts arise in adults from dilatation of the urachus.

That the urachus should dilate and form cysts need not surprise us when we remember how frequently it remains patent in some part of, or even the whole of, its extent.

Lawson Tait, in his work on "Diseases of the Ovary," gives the details of two cases of abdominal cysts which attained very large dimensions, in one case holding as much as ten pints of fluids. These cysts were situated between the fascia transversalis and the parietal peritoneum. Careful consideration of the facts of these cases has led Mr. Lawson Tait to believe that these large cysts originated in the urachus. He further adds: "Although it is perfectly well known, as I myself have repeatedly had occasion to observe, that small cysts of the urachus are opened in abdominal section, I do not know that any such cyst has previously been met with sufficiently large to be of pathological importance." These observations are interesting. For my own part, I believe the cysts are commoner than many suppose, but are unrecognized, and what is more important, there is very good reason to believe that certain rare cases of cystic tumours, of large size, occasionally found between the peritoneum and the sheath of the rectus muscle, take origin in this structure.

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* "Reil's Archiv," Bd. ix., 1809, S. 439.

† "Path. Anat. der Haussaugethiere," 1832, Bd. i., S. 213.

‡ "Arch. f. Heilkunde," Bd. xi., S. 375.

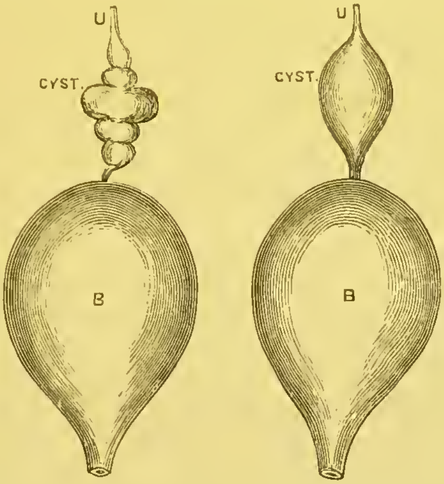

FIG. 61.—URINARY BLADDERS WITH CYSTS DEVELOPED IN THE URACHUS (ALLANTOIC CYSTS).

For further information, consult "The Journal of the Gynæcological Society," London, vol. ii., 1886.

CHAPTER XII.

EXUDATION CYSTS.

Bursæ.—On those parts of the body where muscles, tendons, and skin play over bony protuberances, membranous sacs occur, filled with a glairy fluid. Those found under muscle and skin are usually known as bursæ, or *bursæ mucosæ.* Those under or surrounding tendons are known as tendon-sheaths, or synovial sheaths. In either situation they facilitate the gliding action of skin, muscle, and tendon over hard structures.

Bursæ mucosæ are generally round or oval sacs, the walls of which are composed of transparent connective tissue; but if the bursa has been much irritated so as to lead to inflammation, the walls may be very thick and tough. Sometimes bursæ are loosely united to surrounding tissues; at other times so intimately connected with them that it is difficult to make out the sac-walls.

On opening a bursa the opposed walls will be found separated by a thin glairy fluid, similar to that found in joints and known as synovia.

The internal surface of the sac-walls is usually smooth, but small papillæ are occasionally to be detected, presenting at times a red colour due to a loop of blood-vessels.

The interior is sometimes divided by a network of fibrous tissue. In some cases of chronically enlarged and inflamed bursæ these partitions attain great thickness and convert the cavity into an almost solid tumour. His explains the formation of bursal sacs in the following manner:—When the skin moves over joints, or passes over hard bony prominences, the intermediate connective tissue becomes torn or ruptured, thereby leading to the formation of spaces in which fluid collects. The boundary walls are at first irregular, and formed by the adjacent connective tissue; finally, this becomes smooth and forms the sac-wall. The fact that no complete epithelial lining exists on the walls affords some support to the assumption that these sacs are formed after the fœtus has left the uterus. In certain situations, however, subcutaneous bursæ may be demonstrated in the human fœtus from the eighth month of intra-uterine life up to birth, *e.g.*, over the tuberosity of the os calcis, the base of the fifth metatarsal bone, and under the skin covering the ball of the great toe. Hyrtl has recorded the circumstance in his "Lehrbuch der Anatomie," S. 516 (Vierzehnte Auflage), and I have frequently verified the condition. The presence of these bursæ is a striking illustration of pathological conditions becoming inherited.

Abnormal pressure on projecting parts of a fœtus whilst *in utero* has been known to give rise to a subcutaneous bursa.

Subtendinous bursæ are very constant, and may be demonstrated in the fœtus of man, calves, colts, kittens, etc. Doubtless many subtendinous bursæ arise after birth, but Professor Eichbaum has pointed out* that many bursæ in the newly-born foal and calf are relatively larger than in the older animal, and that bursæ formed before birth have even walls, but those which arise after this event are to be distinguished by their rough fibrinous walls.

Two bursal sacs originally separate may, by enlargement of the cavity, pressure, and gradual thinning of their walls, eventually fuse and form one large bursa.

Many subtendinous bursæ are in communication with the sheaths of tendons and with joints. A good example of this is the calcanean bursa, which communicates with the sheath of the superficial flexor of the phalanges in the horse. In the human fœtus, the large cul-de-sac of synovial membrane of the knee-joint may be demonstrated as a bursa beneath the quadriceps extensor, and in some rare cases it remains as such throughout life.

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* "Bursæ Mucosæ," translated in "Veterinary Journal," vol. xix., p. 335.

The communication between these bursæ and the synovial membranes of joints and tendon-sheaths is the result of absorption of the connective tissue which originally existed between them.

In man, bursæ are often developed as the result of certain kinds of occupation; thus we have the tailor's bursa over the external malleolus, the miner's at the elbow, the monk's or housemaid's on the patella, the weaver's over the tuber ischii, the soldier's over the great trochanter, and the porter's over the clavicle. In the same way in the horse the conditions known as thorough-pin, capped hock, windgalls, etc., denote enlarged bursæ.

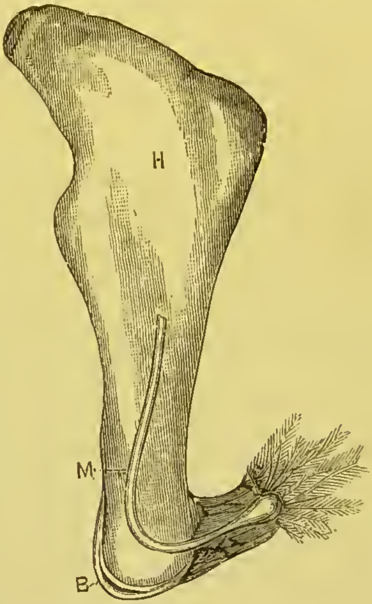

FIG. 62.—STUMP OF A HUMERUS OF A VULTURE AFTER AMPUTATION. B. Bursa developed over the end of the humerus.

These bursal sacs are often a source of trouble to man and beast, as they are liable to attacks of inflammation and may suppurate. If a bursa in the immediate neighbourhood of, or actually communicating with, the cavity of a joint inflames and suppurates, dire consequences ensue, imperilling the life of the animal.

One other curious form of bursal formation occurs at the ends of stumps in man and animals, formed in consequence of amputations. A typical example is represented in Fig. 62, which developed on the end of the humerus of an Egyptian vulture, in whom amputation of the wing had been performed eleven months previously.

Cystomata in connection with the Brain, Spinal Cord, and their Membranes.

The various cysts included under this comprehensive heading are of great importance, in their lesser forms, to the practical surgeon; this adds, therefore, additional interest to their pathological anatomy.

It will be necessary to briefly recapitulate the chief points in the development of the cerebro-spinal axis, because this will afford a sound basis of classification.

At the time when the medullary plates have coalesced, the cerebro-spinal axis may be considered as a nearly perfect tube with three bulb-like dilatations at the anterior end. The imperfections in the tube are, the temporary rhomboidal space at the caudal end, and the rhomboidal space which eventually becomes the fourth ventricle. If the anterior cerebral vesicles do not pass beyond this primitive condition, but dilate into a large cyst, *anencephalia* is the result. Should dilatation occur in the cord, the condition is termed *syringo-myelus.* If the encephalic ventricles proceed in development, and give rise to a brain, and dilatation then occur, it is more or less local, and forms a *ventriculo-meningocele;* it may arise either from the lateral, the third, or fourth ventricle. Similarly, in the cord, a more or less local dilatation of the central canal, accompanied by defect in the laminæ, constitutes a *syringo-myelocele.*

The remaining varieties of spina bifida and meningocele are chiefly affections of the meninges. The various forms of malformation in connection with the brain and cord are compared in the following table:—

Anencephalia.	Syringo-myelus.
Ventriculo-meningocele.	Syringo-myelocele.
Cranial meningocele.	Spinal meningocele.
Meningo-encephalocele.	Meningo-myelocele.

It will be necessary to give a few details concerning each of these varieties.

Anencephalia.—This condition will only be considered in the briefest manner. Typical examples of this malformation occur with tolerable frequency in the fœtus of man and mammals. In these cases the base of the skull is fairly well developed, and the parts in relation with it, but all that portion of the vault of the skull which is preformed in membrane is wanting, as well as the brain; yet the cranial nerves may be found quitting the cranium at their appointed foramina. I have satisfied myself that in some of these cases the base of the skull supported a cyst, which was bounded externally by dura mater, and lined internally by a thin stratum of brain-matter. During delivery the sac ruptures, the fluid contents escape, and the true nature of the case is disguised.

Meningocele and Encephalocele.—The above terms are applied to congenital protrusions or herniæ of the membranes, or of the brain, through the walls of the cranium. The term meningocele is used when the protrusion consists of the membranes, or the ependyma of the ventricles. If brain-matter protrudes, the condition is termed encephalocele. A combination of the two forms is termed meningo-encephalocele. Meningoceles may consist simply of dura mater lined by arachnoid; but in many cases they are dilatations of the ventricles of the brain, and, although they are covered externally by dura mater and skin, their internal lining is continuous with the ependyma of the ventricle. In the case of the calf whose head is represented in Fig. 63, the cavity was directly continuous, by means of a somewhat narrow pedicle, with the cavity of the lateral ventricles. In a case of large meningo-encephalocele occurring in a child, which I reported in the "Path. Soc. Trans.," vol. xxxiii., p. 18, the cyst was formed by the enormously stretched roof of the fourth ventricle, and the corpora quadrigemina projected into the cavity. In position, these cysts may choose the occiput immediately above the foramen magnum, or the anterior, posterior, and lateral fontanelles, the olfactory fossa, or project through the floor of the sella Turcica.

In man by far the most frequent seat for their occurrence is the occipital region. Meckel* long ago pointed out this fact. Laurence† tabulated seventy-five cases, and found that fifty-three occupied this region.

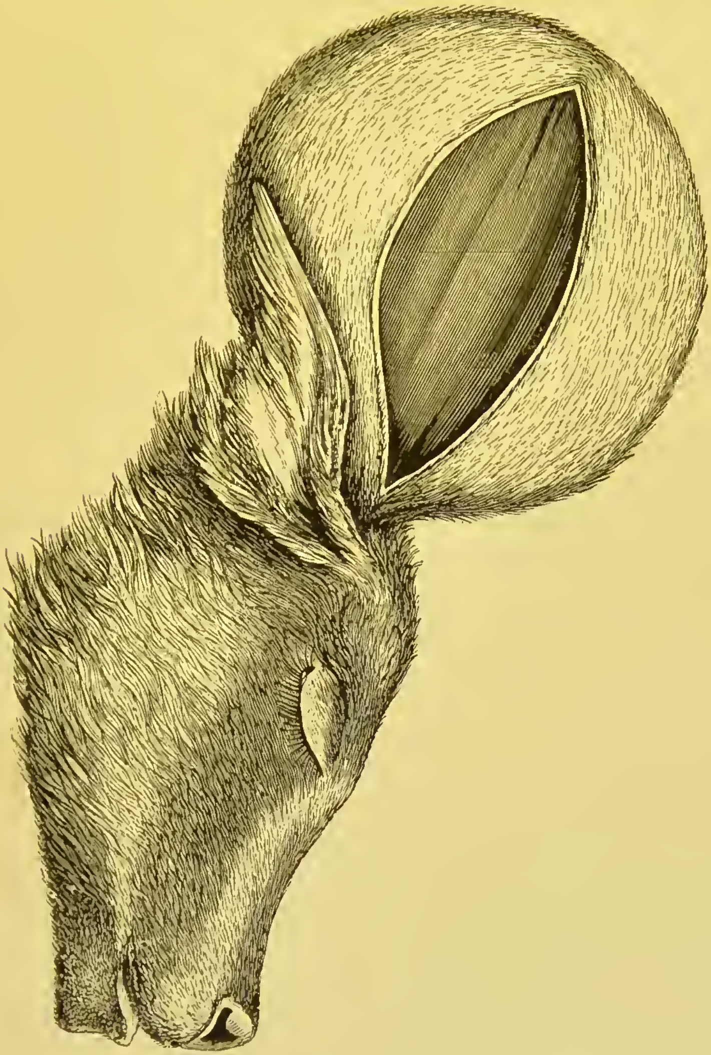

FIG. 63.—THE HEAD OF A CALF, BORN AT FULL TIME, WITH A LARGE VENTRICULO-MENINGOCELE, WHICH COMMUNICATED BY MEANS OF A NARROW PEDICLE WITH THE CAVITY OF THE LATERAL VENTRICLES.

It is curious to note that the protrusion does not come through the foramen magnum, but occupies a "temporary" fontanelle immediately above the foramen, in the squamous portion of the occipital bone. (For a detailed description of the fontanelle consult this reference*.) But the most remarkable instances are those where the hernial protrusion makes its way through the sella Turcica (a spot corresponding to the open arms of the trabeculæ cranii), and projects into the pharynx. Virchow† figures a case of this kind, in which the cyst projected from the mouth. Dr. Lichtenberg‡ reported a case where the cyst projected out of the mouth, hung over the chin, and touched the sternum. These cases are to be regarded as dilatations of the third ventricle. In those instances where the protrusion makes its way through the olfactory fossa, the cyst often causes a projection forwards of the nasal bones, and forms a large pulsating swelling in the upper part of the nasal fossæ. For some excellent figures of meningoceles consult Hutchinson.§

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* "Handbuch der Path. Anat." Leipzig, 1812.

† "Med.-Chir. Soc. Trans.," vol. xxxix., p. 322.

Syringo-myelus.—This term is applied to abnormal dilatation of the central canal of the spinal cord, unaccompanied by defect in the laminæ of the vertebræ. The dilatation may affect only a limited portion of the central canal, or extend the whole length of the spinal cord. In one remarkable case, described by Dr. Norman Moore (" Path. Soc. Trans.," vol. xxxii., p. 7), the spinal cord from a woman, aged 22, was found to be a tube filled with fluid; the central canal, for its whole length, had become so dilated that it easily admitted the little finger. It is probably the most marked example on record. Dr. Frederick Taylor has described two similar cases in " Path. Soc. Trans.," vols. xxix. and xxxv., and gives references to others. The condition is probably congenital; but it is interesting, as affording still further evidence of origin of cysts in functionless tubules.

Although there is evidence in favour of the view that syringo-myelus is a congenital condition, especially in the shape assumed by the dilated canal resembling that found in the early part of intra-uterine life, nevertheless, in cases where the dilatation is complicated by the presence of a tumour, it may originate after birth. This was well shown in the spinal cord of a lion a year old, which died from paraplegia, the result of pressure from rickety epiphyses, as explained on page 53. In the various sections of the cord subjected to pressure the canal was obliterated; but in the intermediate portions the central canal of the cord was dilated three times beyond its natural dimensions. There can be little doubt that in the majority of cases dilatation of the central canal is a congenital defect; nevertheless, it may arise in adult life.

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* "Med.-Chir. Soc. Trans.," vol. lxvii., p. 167.

† "Path. des Tumeurs," vol. i., p. 185.

‡ "Path. Soc. Trans.," vol. xviii., p. 250.

§ "Illustrations of Clin. Surgery," vol. i., p. 5; and vol. xii., plate 45.

Spina Bifida.—The term spina bifida is used to denote a congenital protrusion of some of the contents of the neural canal—meninges, spinal cord, or both in the same case—through a deficiency in the vertebral column. In the majority of instances there is an associated defect of the arches; in *very* rare cases the malformation affects the bodies of the vertebræ, allowing the cyst to project anteriorly. Spina bifida has recently been made the subject of careful study by a Committee of the Clinical Society, and free use will be made of their valuable research.*

Specimens of spina bifida are arranged by this committee in three chief divisions:—

(1) Spinal meningocele.
(2) Meningo-myelocele.
(3) Syringo-myelocele.

Spinal Meningocele.—In typical forms this variety consists of a protrusion of the spinal membranes,—dura mater and arachnoid,—communicating with the general cavities of the spinal membranes, invested with skin, and tending to become pedunculated. In this variety the defects in the arches may be limited to a few, or the cyst may project between the arches of two vertebræ, without any being deficient; or many arches may be deficient, and this without any definite relation to the size of the cyst. It may occur in any region of the spine, and is the one which tends to undergo spontaneous cure.

For further illustration of this form of spina bifida the reader is referred to certain forms of sacral cystomata (page 330).

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* "Clinical Society's Transactions," vol. xviii., p. 339.

Meningo-myelocele.—The majority of examples of spina bifida belong to this group. The protrusion makes its way between defective arches; the bodies of the vertebræ are well formed, and the spinal nerves normal. The wall of the protrusion is formed, except at its summit, of skin and dura mater; the arachnoid is continued over the interior of the space. The spinal cord crosses the back of the sac, and the nerves arising from it pass horizontally forwards, to emerge by their appropriate foramina. In many of these cases, small additional ganglia may be found on the nerves; they are known as *ganglia aberrantia* (Fig. 64).

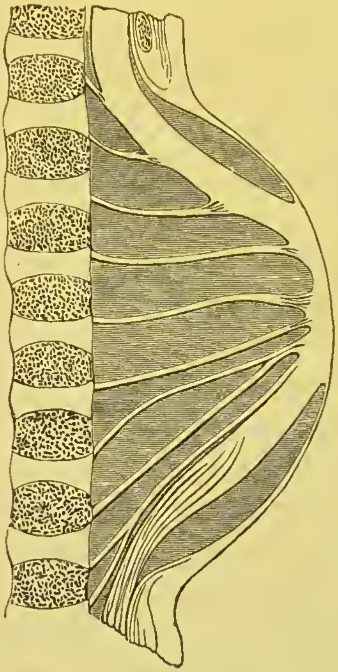

FIG. 64.—A MENINGO-MYELOCELE.

Of the nerves, both roots are present, and at their origin are separated by a falciform process of pia mater, an exaggerated continuation of the ligamentum denticulatum.

Syringo-myelocele.—In this variety there is a protrusion of the membranes, together with the spinal cord, the central canal of which is dilated to form the sac-cavity; the inner lining of the sac is constituted by the expanded and atrophied substance of the cord.

This is the rarest of all varieties, for out of one hundred and twenty-five specimens of spina bifida examined by the Committee of the Clinical Society, only two could be with certainty referred to this variety.

In typical cases, dissection shows on the inner wall of the sac a well-defined layer; on removing this the nerve-roots are exposed, lying in loose connective tissue. In this manner the nerve-roots pass round the sac to the intervertebral foramina. A minute foramen leads from the sac into the substance of the cord, and presumably represents the central canal.

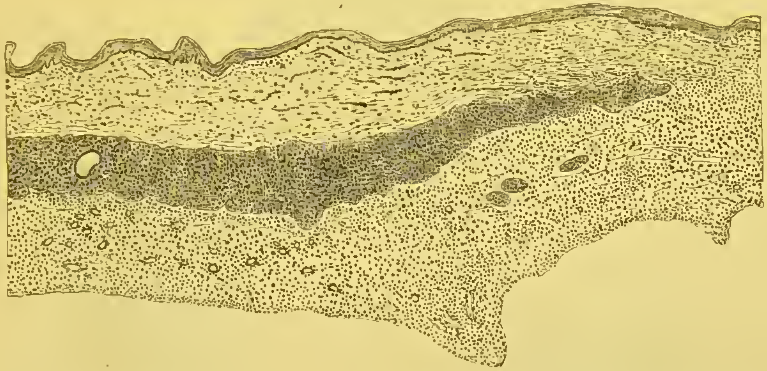

Fig. 65.—Microscopic Section of the Sac-Wall of a Meningo-myelocele in the middle of which lies a portion of the Neural Tissue of the Flattened Cord.

A complete central canal will be seen near the left-hand extremity. (Hartnack, Oc. 4, Obj. 4.)

Förster and other writers have maintained that, in the majority of cases, spina bifida is due to dropsy of the central canal of the spinal cord—that is to say, the majority of them are syringo-myeloceles.

In the "Report" before referred to, the histological examination of the sac-wall in meningo-myeloceles demonstrates an intact central canal, as is shown in Fig. 65, which shows definitely that the medullary plates have coalesced and the canal is undilated.

The following are the conclusions arrived at by the Spina Bifida Committee, regarding the probable mode of origin of the malformation: Fig. 66 represents the normal disposition of the parts concerned. The medullary plates have coalesced to form a complete neural tube, but the mesoblastic somites have not completely invested the tube to form the neural arches of the vertebræ and membranes of the spinal cord.

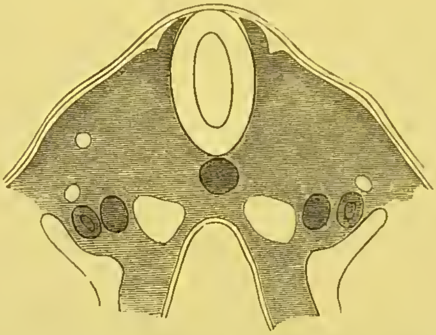

FIG. 66.—SECTION OF AN EMBRYO CHICK AT THE THIRD DAY BEFORE THE FUSION OF THE MESOBLASTIC SOMITES.

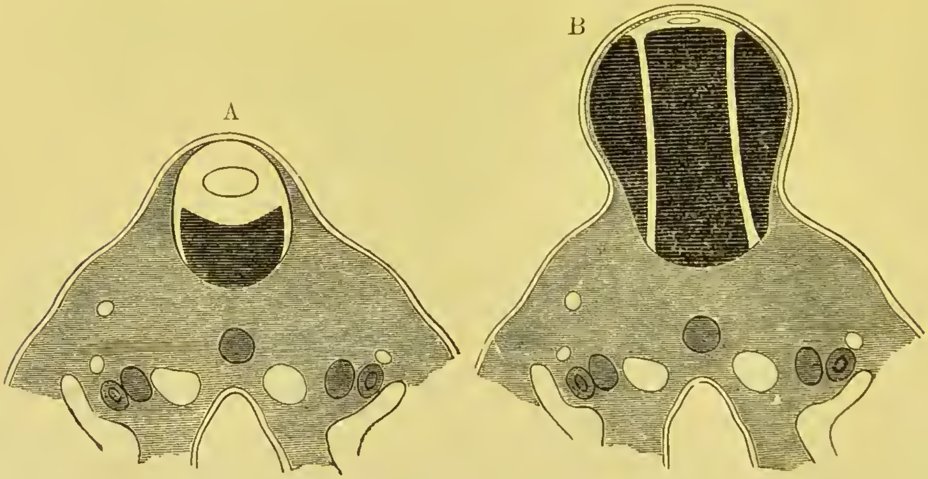

FIG. 67.—FORMATION OF MENINGO-MYELOCELE.

A shows accumulation of fluid in front of spinal cord, no membranes having been differentiated behind.

B shows displacement backwards and flattening of the cord with stretching of the nerve-roots from further accumulation of fluid.

If fluid accumulate in front of the cord, no membranes having differentiated behind on account of the absence of mesoblastic tissue, the cord gets pushed backwards and flattened out, so as to form the posterior wall of the cyst, as in Fig. 67. As a direct consequence of the dislocation of the cord, the nerve-roots and ligamentum denticulatum get enormously lengthened. In these cases the epidermis is continued over the sac-wall, but exactly in the middle line the skin is destitute of hairs or other appendages.

In the rarer form, that of syringo-myelocele, the accumulation occurs in the central canal of the spinal cord, as seen in Fig. 68. The nerve-roots pass round on the outer surface of the cord; whereas in meningo-myelocele the nerve-roots are contained within the fibrous tissue of the sac-wall, and are more conspicuous on the posterior than on the anterior aspect of the cyst.

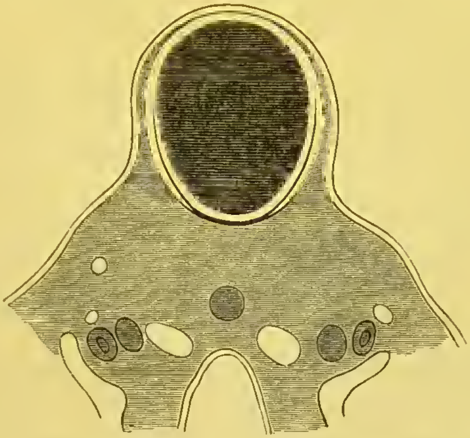

FIG. 68.—SYRINGO-MYELOCELE IN TRANSVERSE SECTION.

The rarest form of spina bifida is that in which the central canal of the spinal cord opens on the summit of the sac. In these cases it is probable that the neural furrow has never closed. The museum of the Middlesex Hospital contains a specimen apparently of this nature. (It is represented on Plate IV. of the "Spina Bifida Report.") This view receives support from some cases reported in chicks, in which closure of the cerebro-spinal cylinder has failed to take place.*

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* Lebedeff: "Ueber die Entstehung der Anencephalie." "Virchow's Archiv," xxxliv., p. 263.

CHAPTER XIII.

CYSTOMATA IN CONNECTION WITH THE FEMALE REPRODUCTIVE ORGANS.

Since Caspar F. Wolff and the two princes among observers in biological science, Rathke and Johannes Müller, worked out the main points in the history of the remarkable series of changes which occur during the development of the mammalian reproductive organs, a sort of fascination seems to have surrounded this subject, to judge from the large number of talented observers in embryology who have been attracted to this difficult question. Before entering into details concerning the pathology of these organs, it will be well to trace briefly the chief points in the formation of the various structures, for unless a clear conception be formed of the development of the parts, some misunderstanding may arise. Later researches, particularly those of Semper and Balfour on the "Development of Elasmobranch Fishes," enable us to recognize three typical parts to these organs, each part consisting of a glandular mass with its correlated duct. These ducts, in the early embryo, open posteriorly into the cloaca. The three segments, which are bilateral, may be thus classified:—

(1) A glandular mass known as the *pronephros*, or head kidney. Its associated duct is known as the Müllerian duct.

(2) The *mesonephros*, or Wolffian body, in relation with the cloaca by means of the segmental or Wolffian duct. The gland is brought into connection with its duct by means of the segmental tubes.

(3) The *metanephros*, or kidney, having for its excretory duct the ureter. This will not further concern us.

A glance at Fig. 69 will help to make the description more intelligible. M^1, M^2, M^3, indicate Müller's duct; W^1, W^2, W^3, the Wolffian or segmental duct, with its transverse tubules and the mesonephros; *u*, refers to the ureter with the metanephros.

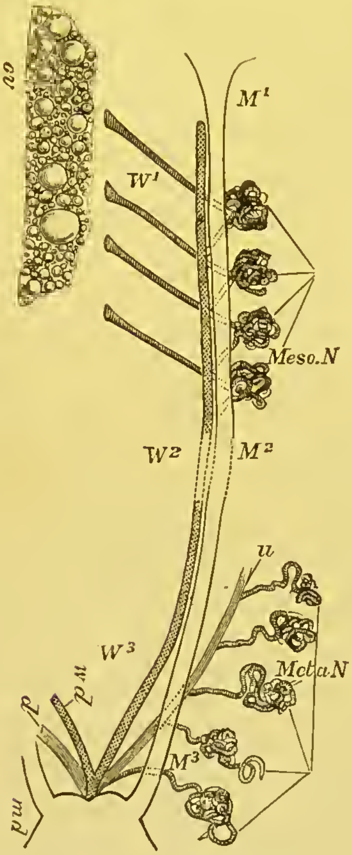

Fig. 69.—Diagram to show the Relation of the Genital Ducts in the Embryo. (After Balfour.)

Of these ducts we are at present concerned with two only, the Wolffian and the Müllerian.

These ducts undergo a series of remarkable changes, which, with the help of a figure, may be thus described:—

(1) *The Müllerian Duct.*—This duct develops into an oviducal passage in the female of most fish, amphibians, reptiles,

and birds, but into a uterus in mammals. The formation of the uterus and its essential parts takes place after this manner.

The Müllerian duct may be conceived as being made up of three parts:—

The upper third becomes the Fallopian tube, the funnel-shaped opening communicating with the peritoneal cavity, and supports a tiny cyst, commonly known as the "hydatid of Morgagni," but for pathological, if not for anatomical, purposes would be much better termed the "Müllerian cyst."

The middle portions of the ducts fuse together, and form the fundus, body, and neck of the uterus, whilst the lower thirds of the Müllerian ducts form a vagina. Such is the commonest arrangement.

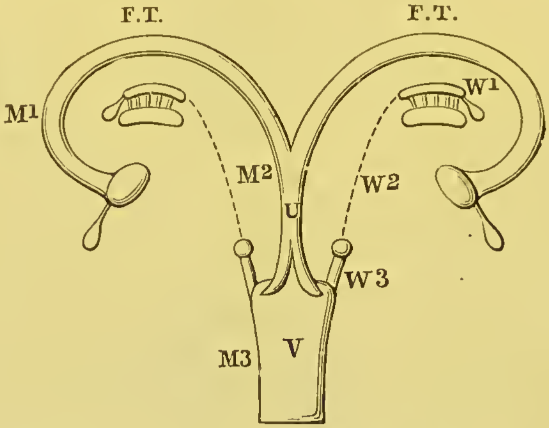

FIG. 70.—DIAGRAM TO SHOW THE METAMORPHOSIS OF THE MÜLLERIAN AND WOLFFIAN DUCTS IN THE FEMALE.

In the accompanying woodcut (Fig. 70), the letters M^1, M^2, and M^3 refer to the three portions of the duct after the metamorphosis.

(2) *The Segmental (Wolffian) Duct.*—This duct and its associated tubules have no function in the female, but the atrophied remains are often to be detected. Like the preceding duct, it may, for the purpose of convenient description, be divided into thirds.

The upper division, with the segmental tubes, may be detected lying above the ovaries in the folds of the broad ligament, and is commonly referred to as the "organ of Rosenmüller," or better, the "parovarium."

The middle portion usually atrophies, whilst the third portion often forms a narrow tube lying in the broad ligament, and, running towards the upper part of the vagina, is recognized as the duct of Gartner (Fig. 70, W^1, W^2, W^3).

The parovarium may be easily seen by holding the mesosalpinx between the eye and the light; then a series of tubules will come into view, radiating from the ovary to join a longitudinal tube situated at right angles to them. Although these tubules converge at their ovarian end, nevertheless they remain distinct; they are lined with epithelium, and each tubule ends blindly. In form and disposition they recall exactly the arrangement of the vasa efferentia and commencement of the epididymis in the male—indeed, it is these ducts which in man constitute that portion of the excretory apparatus of the testicle.

This interesting structure was discovered by Rosenmüller in 1801, whilst prosecuting anatomical researches at Erlangen, and it seems that he was impressed with the resemblance between these tubules and the vas deferens with the epididymis of the male.

The parovarium, a term first used by Kobelt, received a new interest when it was found to be the origin of some forms of cysts which occur in the broad ligament of the uterus.

Gartner's Duct.—This duct, which was first detected in cows and swine by Gartner in the year 1822, is occasionally present in the human female, and may be seen as a tube in the broad ligament of the uterus, but lower in its course becomes incorporated with the walls of the vagina, occasionally opening on the mucous surface of that tube. This functionless duct may become the seat of cystic formations.

For a long time it has been the general opinion among anatomists and morphologists that a pair of ducts situated one on each side of the female urethra were the terminations of Gartner's ducts. These ducts are often referred to as Skene's tubes. This view has been recently challenged by

Schüller, who states that they are simply the outlets of a pair of glands unconnected with the ducts in question.

In the cow, Gartner's ducts are present as exceedingly well-developed structures (see Fig. 41), and although in the majority of instances they terminate in the sides of the cervix uteri, they do occasionally maintain their patency, and open on the free surface of the vaginal mucous membrane as Skene's tubes. Now, the duct of Gartner is the representative in the female of the vas deferens in the male. In the latter, the duct gives off a diverticulum immediately before it terminates on the side of the utriculus masculinus (the homologue of the vagina), known as the vesicula seminalis. In favourable cases I have found a similar diverticulum in the vagina from Gartner's ducts, and it is easy to see that, although Gartner's duct is originally continuous with Skene's tubes, the connection may be disturbed, giving rise to the appearance of a distinct gland. (For further details see "Journal of Anatomy and Physiology," vol. xx.)

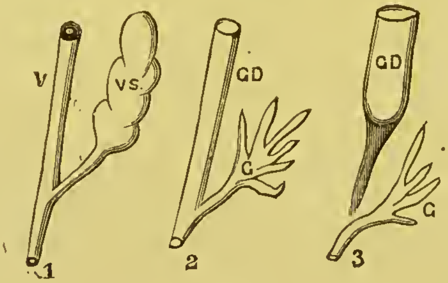

FIG. 71.

To show (1) the Vas Deferens; (2) Gartner's Duct with its diverticulum; (3) its most frequent condition, the duct becoming impervious as it passes through the vaginal wall.

The Generative Gland.—It is unnecessary to enter into all the details concerning the development of the ovary; only those points will be indicated which bear on the pathology of cystic formations.

The generative glands of the male and female are derived from a collection of cells situated at the point of divergence of the mesoblastic somites into somatopleure and splanchnopleure; this ridge of cells is known as the *intermediate cell-mass.* It is very early distinguishable in the chick (forty-five hours). As it increases in size the cell-mass passes into, and blends with, the mesoblastic somites in its immediate neighbourhood. The aspect of the genital ridge which looks towards the body-cavity becomes covered with a layer of cells continuous with the peritoneum.

The genital ridge is a projection from the intermediate cell-mass, and the cells which cover the ridge may be traced continuously with those of somatopleure and splanchnopleure. As the ridge increases in size, the columnar character of the cells becomes more restricted to those covering the ridge itself, and these become several cells deep, whilst the underlying mesoblast increases in thickness. A few of the cells now become conspicuous on account of their size, and possess a refractive oval nucleus of considerable bulk. The large conspicuous cells, which have a common origin with their fellow-cells, are the primordial ova or germinal cells.

In the female these multiply in number, and the mesoblast underlying them also increases, giving rise to the stroma of the ovary. Eventually each ovum becomes invested by a capsule of connective tissue lined internally by a layer of epithelium, the whole constituting a Graafian follicle.

The number of ova which a single ovary contains is marvellous; Waldeyer computes the number in the two ovaries of an infant at birth at about 300,000.

It is well known that at the age of puberty these follicles ripen, and an ovum is discharged; this occurs in the healthy human female at or before each menstrual period.

After the discharge of its contents, the Graafian follicle becomes filled with blood, which is later replaced by a peculiar yellow body, the well-known corpus luteum, which is of small size if the ovum escape impregnation, but of much larger proportions if fertilization takes place.

It is the usual and generally-received opinion that corpora lutea are only formed at the period of puberty and during the course of sexual life; that is to say, they remain latent until this period. If the ovary of a fœtus at birth be compared with one at the twelfth year, or at puberty, there will be found a marked diminution in the number of ova in the latter. Now, Waldeyer and Beigel* have stated that the follicles ripen, atrophy, and form a kind of corpus luteum during the period between birth and puberty. My own observations confirm the truth of this statement in every particular, and I shall return to this matter again, for it has a most important bearing on the origin of ovarian cysts.

Before discussing the etiology of ovarian cystomata, it is essential to draw attention to another point in the anatomy of the ovary. The adult organ consists of two very distinct parts, viz., the tissue of the hilum, and the true ovarian parenchyma. Thus the ovary is divided into two parts histologically distinct, as they are also in the manner of their development. The ovarian parenchyma will be referred to as the *oophoron*. The tissue composing the hilum is exceedingly vascular, and contains the remains of the mesonephros, and receives the vertical tubes of the parovarium. This portion will be referred to as the *paroophoron*. This statement applies especially to the human ovary; how far it is true of other ovaria requires investigation, but it is certain that many animals present this disposition of parts: before long it is hoped that further information will be forthcoming. The question is a very important one in its bearing on the origin of cysts in connection with this region of the ovary.

This brief sketch of the fundamental constitution of the female reproductive organs demonstrates that we have to deal with the following elements:—

(1) Ovarian parenchyma—the *oophoron*. (2) The remains of the mesonephros (Wolffian body)—*paroophoron*. (3) The *parovarium*, or Wolffian tubules. (4) The duct of the mesonephros, or Gartner's duct. (5) Müller's duct, its representatives being the vagina, uterus, and Fallopian tubes. These structures form a useful basis of classification:—

1. Ovarian cysts—(*a*) originating in the *oophoron*; (*b*) originating in the *paroophoron*.
2. Parovarian cysts—arising in the Wolffian tubules.
3. Simple cysts of broad ligament—lymphatic?

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* "Archiv für Gynäkologie," Bd. xiii., 1878.

4. Cysts of the duct of the mesonephros (Gartner's).

5. Cysts in Müller's duct—(*a*) hydrosalpinx, etc.; (*b*) pyometra; (*c*) oviducal cysts.

Cysts of the Oophoron.—It would be absolutely waste of time to endeavour to discuss all the various modes by which cysts have been supposed to arise in this organ; but there is every reason to believe that ovarian cystic disease, in a very large number of cases, originates in some arrest of the downward progress of the normal degeneration of the atrophying follicles.*

We must now endeavour to discuss the evidence in favour of this view. In the "Path. Soc. Trans.," vol. xxxvi., I published a detailed account of some investigations into the disease of the reproductive organs of animals. Among the specimens there described is a transverse section of a mare's ovary, showing a corpus luteum, the interior of which has broken down, giving rise to the formation of two small cysts (Fig. 72).

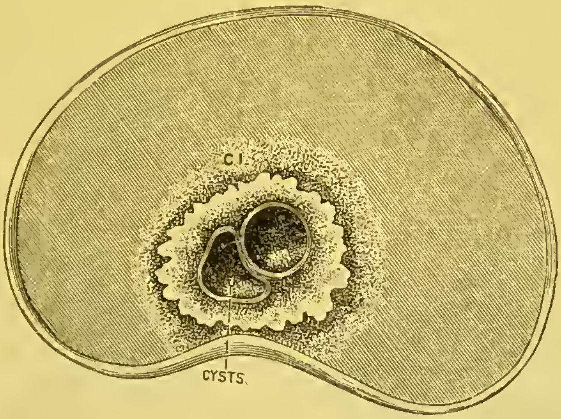

FIG. 72.—TRANSVERSE SECTION OF A MARE'S OVARY WITH A CYSTIC CORPUS LUTEUM. (Semi-diagrammatic.)

This furnished an important indication as to the probable origin of many of those cysts which are so common in the ovaries of mares which attain adult life.

The further investigation of this question was carried out on the ovaries of cows, and the result has been in the highest degree satisfactory, for it shows that ovarian cysts do arise very frequently in corpora lutea.

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* Rokitansky: "Pathological Anatomy." Doran: "Tumours of the Ovary."

The investigation was carried out on the uterus and its appendages, taken from seventy cows of all ages, and under varying conditions of health and disease. An examination of the ovaries enabled me to trace the different stages of cystic formations. In the above series of drawings the following conditions are depicted:—Fig. 73 A is a normal

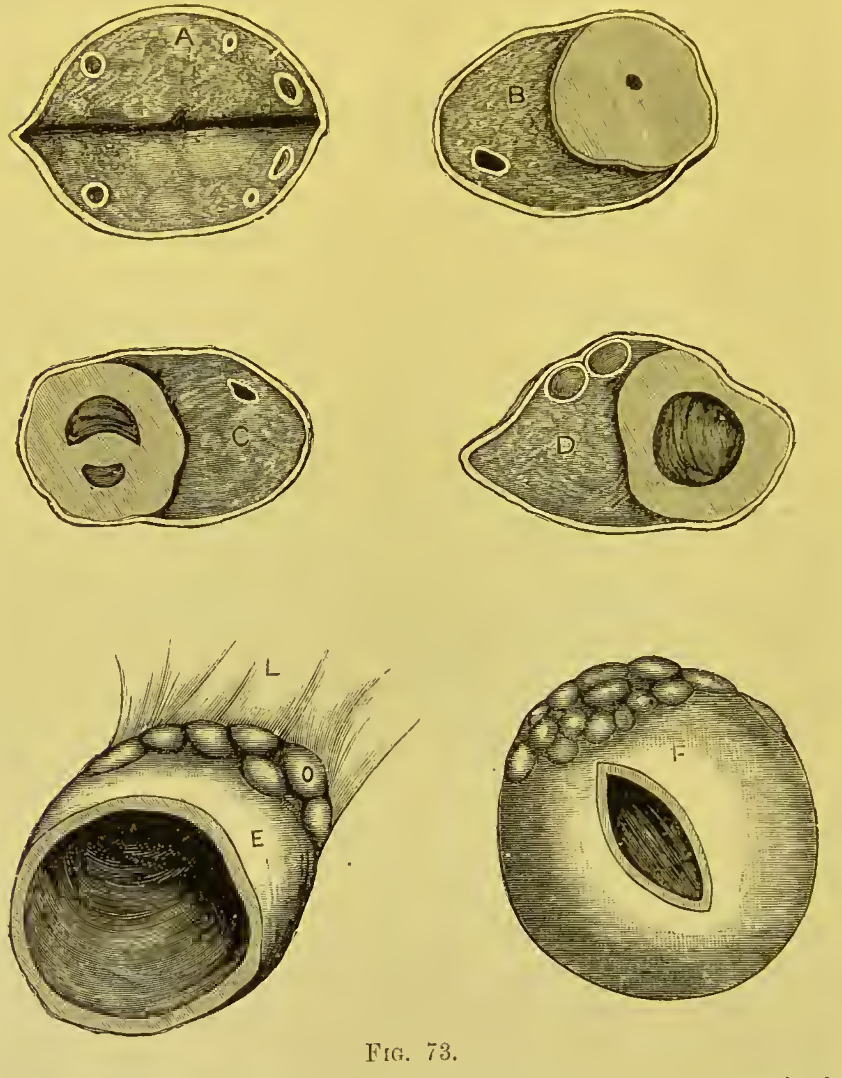

FIG. 73.

A series of Figures to represent the various stages of formation of Cysts in the Parenchyma of the Ovary in Corpora Lutea (see text). Figs. A to E are from Cows; F is the Cystic Ovary of a Tigress.

cow's ovary seen in section; the small cysts are mature follicles. Fig. B, a similar ovary with a corpus luteum of pregnancy. Fig. C, a corpus luteum with two cysts in early stage of formation. Fig. D, an advanced stage of a cyst in the interior of a corpus luteum. Fig. E, a still further stage, the cyst being of the size of a small orange: its walls are composed in chief part of the peculiar yellow material so characteristic of corpora lutea. In Fig. D, two small cysts are seen near the margin of the cut section; and on looking carefully at Fig. E, minute cysts, O, are seen dotting the surface of the main cyst: this arrangement of the parts is easily explained, for as the main cyst grows it spreads out the ovarian tissue, which thus goes to form parts of its walls, and any other cyst it may contain becomes incorporated with the main one. If, perchance, these cystic spaces increase in size, a multilocular cyst will be formed. Fig. 73 F is the ovary of a tigress, with a fair-sized cyst, thus expanding the ovary, and other minute cysts stud the walls.

These specimens show most conclusively that cysts do arise in corpora lutea in cows, as well as in mares, in asses, and in tigresses. I have also seen them thus arising in monkeys and in women. In pigs their presence may be easily demonstrated.

Other examples of cysts arising in a tigress in this way are represented in Figs. 74 and 75. Some of them are pedunculated, and probably arose in the parovarian tubules.

Cysts similarly arising may be detected in the ovaria of birds and snakes, especially among the larger species.

Ovarian cysts, such as have been described as arising in corpora lutea, are found at all ages, from infancy up to the end of sexual life, and the question that suggests itself is this: if the cysts arise in these retrograde follicles in adults, how can cysts in the ovaries of infants be explained? It has been already mentioned that Waldeyer and Beigel maintain that the follicles ripen, atrophy, and form corpora lutea in the child, and ripe follicles are frequently present in the ovary at, and even before, birth.

With the view of testing this statement I have systematically examined ovaries from human fœtuses at birth, and have found several examples of cystic ovaries, and, what is more to the point, I have demonstrated, to my own satisfaction as well as to others', that follicles do ripen in the fœtal ovary, and that cysts arise therein.

With these facts before us it is difficult to dispute the origin of parenchymatous ovarian cysts from corpora lutea. The explanation is a simple one, and capable of easy demonstration, and is applicable to ovarian cysts of snakes, birds, mammals, and human beings.

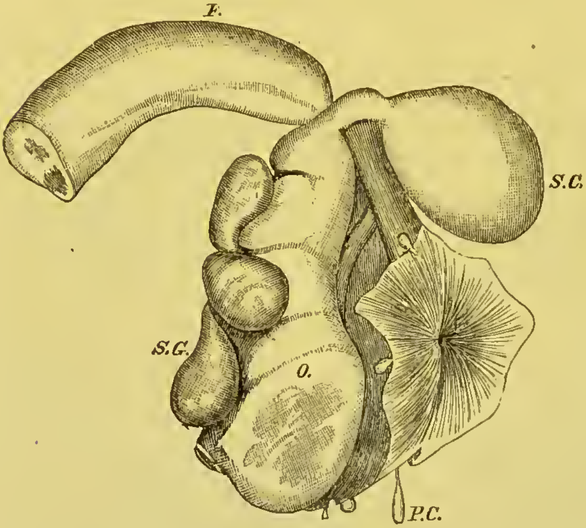

FIG. 74.—OVARY AND FALLOPIAN TUBE OF AN OLD TIGRESS.

O, ovary transformed into cysts. *S.G.*, solid growths which are really hypertrophied corpora lutea. *P.C.*, pedunculated cysts. *S.C.*, serous cysts originating in the organ of Rosenmüller.

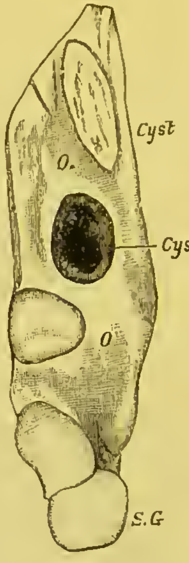

FIG. 75.—TRANSVERSE SECTION OF THE OTHER OVARY, SHOWING CYSTS IN THE INTERIOR OF THE ORGAN.

S.G., the hypertrophied corpora lutea in transverse section.

Some parenchymatous cysts of the ovary arise in follicles which have never ruptured, for ova have been discovered in the cysts in a few instances, but they are the rarer kind; by far the greater number undoubtedly have their origin in corpora lutea.

For a full discussion of this subject, the reader is referred to a paper in the "Journal of Anatomy and Physiology," vol. xx.

Cysts of the Paroophoron.—In describing the ovary, attention was drawn to the fact that this organ consists histologically of two parts—the stroma or parenchyma, and the tissue of the hilum. This latter portion is very vascular, and consists essentially of the remains of the mesonephros (Wolffian body). It is from this tissue that we have arising cysts with firm papillomatous growths sprouting from their inner walls, known as papillary cysts.

There is every reason to believe that this variety of tumour originates in the tubular structures which are relics of the mesonephros. In one well-reported case, by Doran, two small incipient cysts with papillary contents were detected in the tissue of the hilum in a seven-months fœtus. In one case which came under my notice, in a fœtus born between the eighth and ninth month, and in whom cystic ovaries were found, not only could papillary cysts be detected, but the Wolffian tubules were of considerable size, and in some parts the ciliated epithelium was wonderfully distinct. In this instance, also, there was very little ovarian stroma that could be detected; the remains of the mesonephros (Wolffian body) seemed to have completely usurped the true ovarian tissue.

Not only in the female, but also in the male, as will be presently pointed out, the remains of the mesonephros, as the paradidymis, have a great tendency to form cysts known as encysted hydrocele. Among other things, it must not be forgotten that the curious plexus of veins called the pampiniform plexus are the dilated tortuous venules which originally ministered to this curious structure.

Parovarian Cysts.—In the females of nearly all mammals, the tubules of the parovarium exhibit a marked disposition to dilate and form cysts. If they become pedunculated, as is so often the case, the pedicle becomes twisted, interferes with their nutrition, and the cyst rarely attains a size above that of a nut, but is usually smaller; if no torsion occurs they may attain the size of an orange, and become detrimental to the individual who possesses them.

For the general appearance and relation of this interesting relic in the female, the reader is referred to the figure given on p. 219. In the accompanying drawing (Fig. 76), the uterus of a cat, immediately after delivery, is represented, and many pedunculated cysts are seen on the left side. Cysts of this kind are exceedingly common in animals as well as among human females. The following is a list of the animals in whom I have found them:—Monkeys, tigers, and cats of all kinds, goats, deer, kangaroos, horses, cows, swine, antelopes, and probably in every kind of mammal. In size they vary from that of a pea to that of a Tangerine orange. Frequently their dimensions equal a walnut; cysts beyond this size are rare.

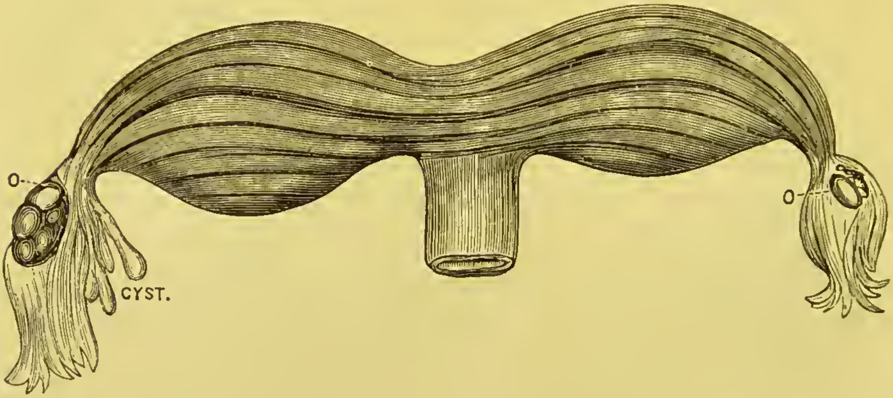

Fig. 76.—Uterus of a Cat immediately after delivery.

Several pedunculated cysts of parovarian origin are shown.

Before deciding whether a given cyst of the uterine appendages should be described as parovarian, it is necessary to bear in mind the close analogy which exists between them and simple cysts of the broad ligament. It is in some cases difficult to decide between the two varieties (see p. 208).

Cysts arising in Gartner's Duct.—These tubes or ducts are not only interesting in that they may become the seat of localized inflammation, but they are occasionally the seat of cystic formations, not merely in the human female, but in animals.

The clearest and best described example of a cyst originating in this duct, known to me, will be found in

Virchow's "Archiv für Pathologische Anatomie," Band xcvi., Heft 1, S. 100. Carl Rieder there contributes a paper of considerable interest, entitled "Ueber die Gartner'schen (Wolff'schen) Kanäle beim Menschlichen Weibe," wherein the literature and frequency of persistence of this structure in various animals, including man, are ably discussed. Not the least interesting point in the paper is the description of a preparation from the collection of the Pathological Institute at Basel, of a case of multiple cysts in the walls of the vagina of a woman, aged twenty-eight years, who died in the fifth month of pregnancy. Rieder's object is to prove—and this he does very conclusively—that the cysts in question were the result of abnormal dilatation of Gartner's ducts.

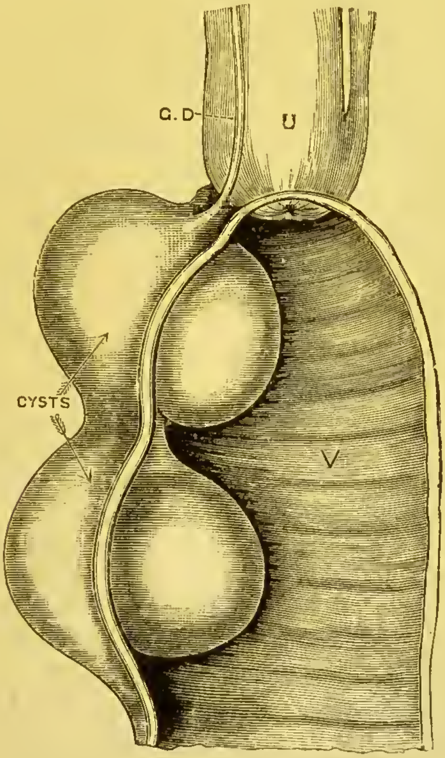

Fig. 77.—Cysts in the Vagina of a Cow, arising as Dilatations of Gartner's Duct.

V, vagina. G.D, Gartner's duct. U, uterus.

The most conclusive case that has come under my notice, of vaginal cysts arising in these ducts, occurred in a cow. The parts are shown in Fig. 77, where the duct may be traced on to the walls of the cysts (each of which would accommodate a hen's egg), with which it becomes insensibly blended. Smaller dilatations are of very frequent occurrence.

Coblenz* has endeavoured to show that papillomatous cysts, which are sometimes found in the wall of the uterus, have their origin in this duct.

Simple Cysts of the Broad Ligament unconnected with the Parovarium.—Doran† draws forcible attention to simple cysts of the broad ligament unconnected with the parovarium. Concerning them he writes :—" Far away from the parovarian tubes, some minute cysts are often observed, adherent, as a rule, to the anterior layer of the broad ligament. They are most plainly visible anteriorly, through the ligament, when the specimen is fresh. When developed beneath the reflexion of the peritoneum over the upper border of the Fallopian tube, they are often pedunculated, as they can more readily push the serous membrane upwards, than insinuate themselves between the layers below the tube. Still, even in this position, the cyst may be perfectly sessile. In some cases the cysts may become pedunculated, even when they are developed in the folds of the broad ligament below the tube, and sometimes several such pedunculated cysts hang like tassels from the ligament. As a rule, however, these cysts, when they increase in size, push apart the layers of the broad ligament " (p. 47).

Doran then adduces evidence to show that these cysts are independent of the parovarium, and his reasons are, to my mind, conclusive. After satisfying myself that the separation of these cysts from those of parovarian origin is legitimate, I set to work to search for corresponding cysts in the broad ligaments of animals. The result of the inquiry has been satisfactory.

The first case of simple broad ligament cysts, which I recognized as such, occurred in a sow. Three cysts were present, one lying in the fringes of the Fallopian tube, the second lying in the concavity of that structure as it curls around the ovary, and the third situated in the mesosalpinx a few lines below its reflexion around the tube, in about the middle of its course. All the cysts are distinct from the parovarium.

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* "Virchow's Archiv," Bd. lxxxii. and lxxxiv.

† Doran : "Tumours of the Ovary, etc."

Such cysts are not uncommon in pigs. Three or four cases were found in fifty specimens examined, but they were single, and in no case did they attain a larger size than a nut, and in none of the examples were the cysts provided with a peduncle.

Opportunities of dissecting simple broad ligament cysts in mares have occurred to me. They were situated between the layers of the mesosalpinx, possessed thin walls, and were filled with fluid. Running among the cysts, and in relation with one of them, were large dilated lymphatic vessels. There was no difficulty in detecting them, for, on account of the ovary being occupied by three cysts of the size of oranges, there had been obstruction to the lymphatic channels, leading to their engorgement. When the animal was killed, the lymph coagulated, and answered all the purpose of an artificial injection, so that in this case it was an easy matter to show that the cysts in question are to be regarded as dilated lymphatics. That this is so in all instances of broad ligament cysts with thin walls and fluid contents is, of course, impossible to state; but it is well known that lymphatics are very abundant immediately beneath the great serous membranes, and this is especially true of the broad ligament of the uterus.

The Müllerian Duct.—In mammals this duct may become distended by accumulation of fluid in its interior in any of its three primary parts—(1) the Fallopian tube, constituting hydro-, pyo-, or hæmato-salpinx; (2) the uterus, giving rise to a condition termed hæmatometria or pyometra; (3) distension of the vagina due to an imperforate hymen.

In other animals, such as frogs, birds, reptiles, etc., there is absence of a distinct uterus, the duct being represented as a more or less simple tube; nevertheless in these forms it is exceedingly prone to take on cystic dilatation in one or more portions of its course.

It will be most convenient to begin with the Fallopian tubes in mammals.

Dilatation of the Fallopian Tubes.—If from any cause the Fallopian tubes have their lumen obliterated, either by an abnormal adhesion to the ovary occluding the *ostium abdominale*, or by inflammation spreading from the uterus leading to closure of the *ostium uterinum*, the intermediate portion becomes dilated, the walls of the tube thin and present all the appearances characteristic of a thin-walled cyst. The contents of such cysts vary in their character. If filled with simple secretion, the condition is known as hydro-salpinx; if blood, hæmato-salpinx; when distended with pus, it is referred to as pyo-salpinx. There can be little doubt that these conditions result from inflammation, for in almost all cases the distended duct has contracted adhesions to the surrounding viscera—rectum, ovary, uterus, or the intestines. Typical cases of double hydrosalpinx are figured in most of the text books on gynæcology (see particularly Lawson Tait, "Diseases of the Ovaries"). The most probable cause of this condition is inflammation arising in the ovary itself, or spreading to the tubes from the vagina and uterus.

It is necessary to distinguish between distension of the tubes arising in this way, and that due to retention of fluid as a consequence of stenosis or complete occlusion of the os. It is usual to find, in cases of this kind, considerable dilatation of the cavity of the uterus; and the Fallopian tubes present also a funnel-shaped dilatation, the base of which is towards the cavity of the uterus.

This abnormal condition of the Fallopian tubes is not confined to the human female, as the following case will serve to show:—

In June, 1884, a kangaroo died in the Zoological Gardens from peritonitis. The abdomen was considerably distended, and the viscera matted together by adhesions of some old date. On examining the pelvic viscera, two swellings were found occupying the Fallopian tubes.

As the uterus and its appendages are somewhat complicated in the marsupials, it will be advisable to give a short description of the parts as seen in the normal condition. In Fig. 78 is represented the vagina, which has passing off at its upper extremity two tubes, the lateral canals, which open eventually into the uterine cavity (median canal), which below forms the median chamber, ending usually in a cul-de-sac. From the upper end of this median chamber the orifices of the Fallopian tubes may be seen when the median canal is slit up. The ostia of the tubes present the usual fringed appearance, lying in close proximity to which may be seen the diminutive ovaries. The exact functions of the various parts of this complicated organ are not thoroughly understood by anatomists. The points about which information is required are these :—Do the young pass down the median canal, and establish an opening between the uterus and vagina, or do they come by way of the lateral canals? Or, are the lateral canals for the passage of semen only?

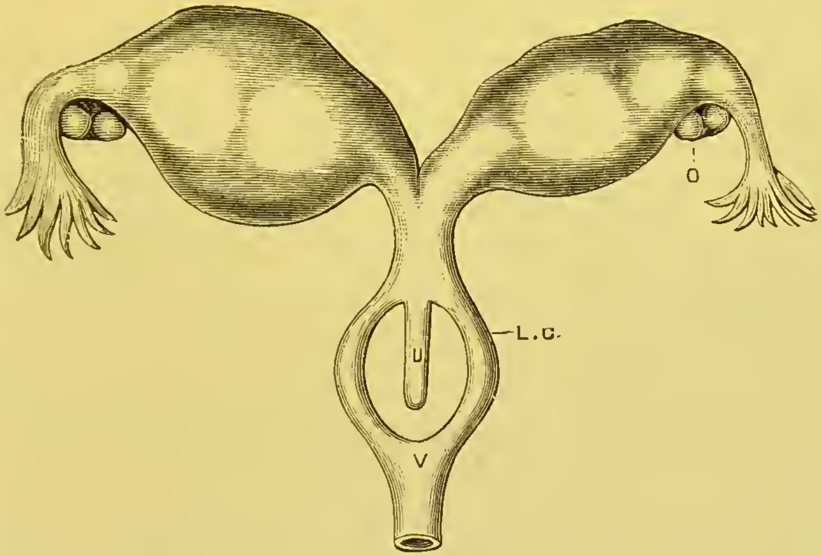


FIG. 78.—UTERUS AND APPENDAGES OF A KANGAROO.

The Fallopian tubes were in a condition of pyosalpinx.

Messrs. Lister and Fletcher published an admirable *résumé* of the question in the "Proc. Zool. Soc.," 1881, entitled

"The Vaginal Apparatus of the Macropodidæ." The following is a summary of their research:—

(1) In the very early condition of the Macropodidæ the median canal is closed.

(2) In some genera, viz., Macropus, Halmaturus, Petrogale (Dorcopsis and Dendrolagus), an opening is formed in the median canal, to give passage to the young. This may take place in early life (Halmaturus), or not until the young are about to be produced (Macropus).

(3) In the species *Macropus major*, however, this opening may or may not exist, and the young are transmitted either through the median or lateral canals.

(4) In Hypsiprymnus, the median canal remains closed, and the young pass down the lateral canals, which differ in their structure from those species just quoted.

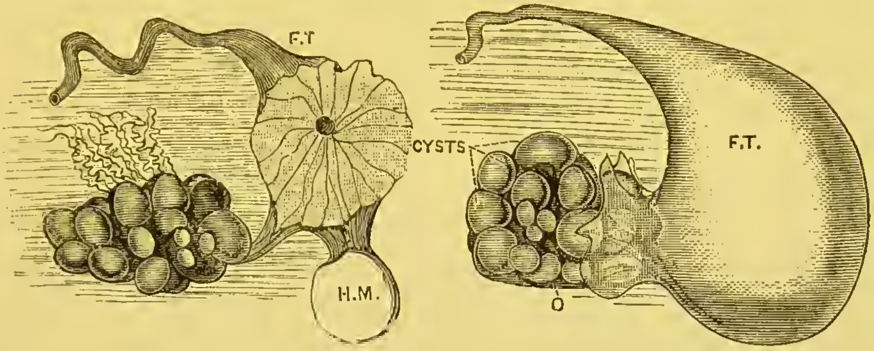
The normal anatomy and probable function of the various parts have been detailed, because they have an important bearing on the case before us. In all examples of marsupial uteri coming under my notice, a large quantity of mucus was present in all these passages. It seems to me that the very trifling amount of inflammation necessary to arrest the flow of secretion through the lateral canals, in cases where the median canal is imperforate, readily accounts for the distension of the Fallopian tubes. On opening these tubes in the present case, they were found filled with pus and caseous material. My opinion is, that this purulent matter gradually leaked into the peritoneal cavity through the abdominal openings of the Fallopian tubes, and had given rise to recurring attacks of peritonitis, which eventually proved fatal.

I have been fortunate also in finding a hydrosalpinx in a kangaroo, and in a cow.

The accompanying drawings (Figs. 79 and 80) represent an example of hydrosalpinx which was found with three others in the uterine appendages of some sows. Fig. 79 is introduced in order to show the normal size of the tube.

Through the kindness of Principal Robertson, I have had an opportunity of examining the uterus of a cow in whom a hydrosalpinx existed, forming a cyst as large as an orange, and it is of more value inasmuch as the case had the following history:—The animal had had one calf, and every means were tried to obtain other calves from her, but without success. Eventually she was fattened and killed; the reproductive organs were sent to the Royal Veterinary College, London.

On examination, the trumpet-shaped ends of the Fallopian tubes were adherent to the ovaries; the latter were cystic, and on the left side the tube was dilated and filled with fluid, forming a cyst as described above. The case is interesting in that it shows the effect of hydrosalpinx in preventing pregnancy.



FIGS. 79 AND 80.—FALLOPIAN TUBES OF SOWS.

Fig. 79 is normal; H.M., hydatid of Morgagni. Fig. 80 is a dilated tube—hydrosalpinx.

Pyometra, etc.—If from any abnormal cause the os uteri becomes occluded, the secretions will be retained. The result of this retention is dilatation of the uterus, and later of the Fallopian tubes. The distension of these tubes from this cause differs from the condition known as hydro- or pyosalpinx, in that distension commences at the uterine end.

The retained secretions in some cases become purulent, and the condition is recognized as pyometra. It occurs in cows, ewes, and dogs, as well as in women.

Dilatations of the Vagina.—Abnormal dilatation of this tube is now and then the result of imperforate hymen.

The continual retention and accumulation of secretions and menstrual fluid lead to its distension.

The Müllerian Ducts in Frogs, Toads, and Birds.—At the outset attention is invited to certain abnormal conditions of the Müllerian duct in male frogs and toads, which will go to show *that it is a condition exceedingly common for functionless ducts to become cystic in animals.*

In the male of the common frog, *Rana temporaria*, the generative organs have the disposition exhibited in Fig. 82. They may be thus described:—On each side is seen the testis, surmounted by the corpus adiposum, with U, the duct which functions as the vas deferens as well as a ureter: V.S. are the vesiculæ seminales with the Müllerian ducts, which in the female become enlarged to function as oviducts; they are seen as delicate thin streaks ascending in the peritoneum, from the summit of the vesiculæ to the root of the lungs, M.D.

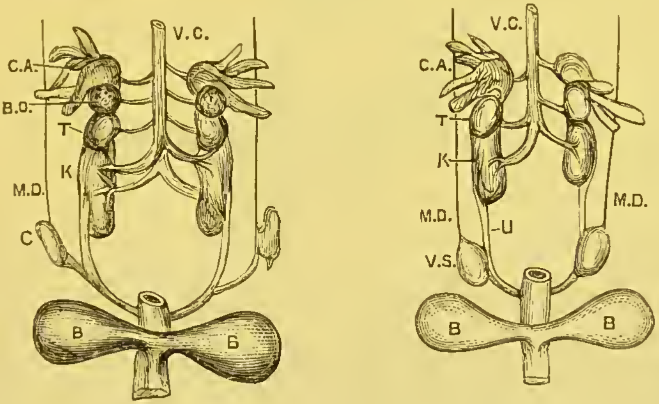
Although the vesiculæ seminales in the frog give one the impression that they are dilatations of the Müllerian duct, nevertheless, as a matter of fact, they belong to the duct of the mesonephros; but their mode of origin has no bearing on the subject of this paper, and will not be considered any further.

In the toad, *Bufo vulgaris*, the most important features are these:—Between the testis and the fat body is a singular structure, called, in honour of its discoverer, "Bidder's organ." This organ, according to the most recent researches, is nothing more or less than a rudimentary ovary, and as such seems to exercise a very remarkable influence on the degree of development of Müller's duct in the male toad.

In frogs, as we have seen, the Müllerian duct in the male is scarcely perceptible, but now and then it happens that a frog sometimes develops a "Bidder's organ," or ovary in conjunction with the testis, forming what amounts to an ovo-testis, and, singularly enough, the Müllerian duct or oviduct then assumes some considerable size. For the purpose of testing this question in toads, more than two hundred and fifty have been examined. It would appear that, as a rule, *the amount of development of these ducts is in direct proportion to the size of "Bidder's organ."* But the point which concerns us most as pathologists is, that it is exceedingly common to find a *cyst* developed in these rudimentary oviducts in the toads. A characteristic example of the cystic condition is shown in Fig. 81, *c*, so that these batrachians afford ready and indisputable examples of *functionless ducts becoming cystic in parts of their course.*

A cystic condition of these ducts may be found in ten per cent. of male frogs, and in fifteen per cent. of male toads.

In birds, as in frogs and toads, upon the Müllerian ducts devolve the duty of safely conveying the ova from the peritoneal cavity to the exterior. In the early chick both Müllerian ducts and ovaries are equally developed, but in the mature bird the left duct and ovary alone persist, the right having atrophied. In the majority of birds no trace of the right duct remains, except a small tube, about an inch long, attached to the right side of the cloaca, often bearing on its summit a small nodule of fat, the degenerated representative of the remaining portion of the duct.



Toad. Frog.

Figs. 81 and 82.—Reproductive Organs of a Male Frog and a Male Toad.

C, Cyst developed in Müller's duct on each side, in the Toad.

V.C. Vena cava. C.A. Corpus adiposum. B. Bidder's organ. T. Testis. K. Kidney. U. Ureter. M.D. Müller's duct. B. Bladder. V.S. Vesicula seminalis.

The persistent left oviduct may be thus described:—

In the quiescent state the duct is nearly straight, but during the breeding season it undergoes considerable enlargement and becomes convoluted. It is maintained in position by a fold of the peritoneum, and extends from the cloaca posteriorly, and terminates anteriorly by opening into the peritoneal cavity just below the ovary, by a funnel-shaped termination known as the infundibulum. It will be convenient to describe this tube as made up of four parts—

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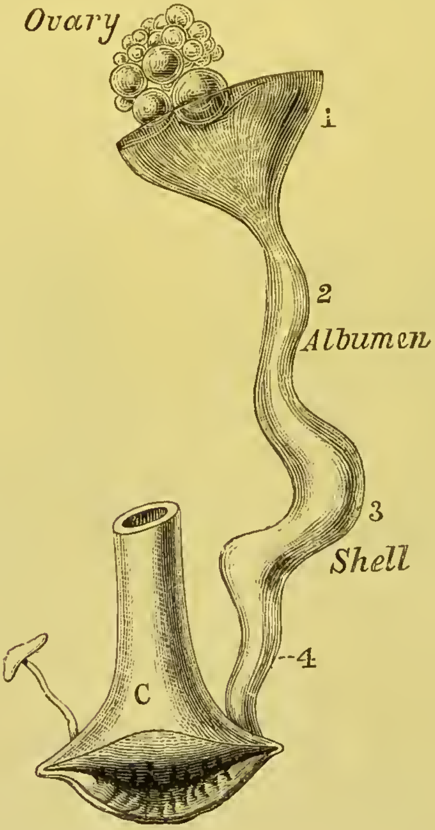

FIG. 83.—REPRODUCTIVE ORGANS OF THE FEMALE BIRD.

(Diagrammatic.)

1st. The dilated infundibulum, with its thin delicate walls; this is followed by the

2nd portion, long and tubular, constituting the oviduct proper; this opens by a narrow constricted portion into the

3rd, or uterine part, which is much larger than the other divisions of the tube, and possesses fairly thick muscular walls.

4th. This is somewhat narrow, and leads from the uterine portion into the cloaca. The oviduct is lined throughout with mucous membrane covered by ciliated epithelium. In some parts of the tube the mucous membrane is thrown into spiral ridges. The various portions of the oviduct are indicated in Fig. 83 in a diagrammatic manner.

When the ovum escapes from its follicle in the ovary, it, as a rule, falls into the infundibulum of the oviduct, passing thence into the second and third portions of the tube; during its passage through the second portion, or oviduct proper, it acquires a layer of albumen, and the spiral motion given to the egg by the ridges in the mucous membrane as it descends, form the chalazæ (because these bands contain little white spots, hence χάλαζα, hailstone), or twisted bands formed of denser albumen attached to the two opposite portions of the yolk; later on, the chalazæ are also enveloped

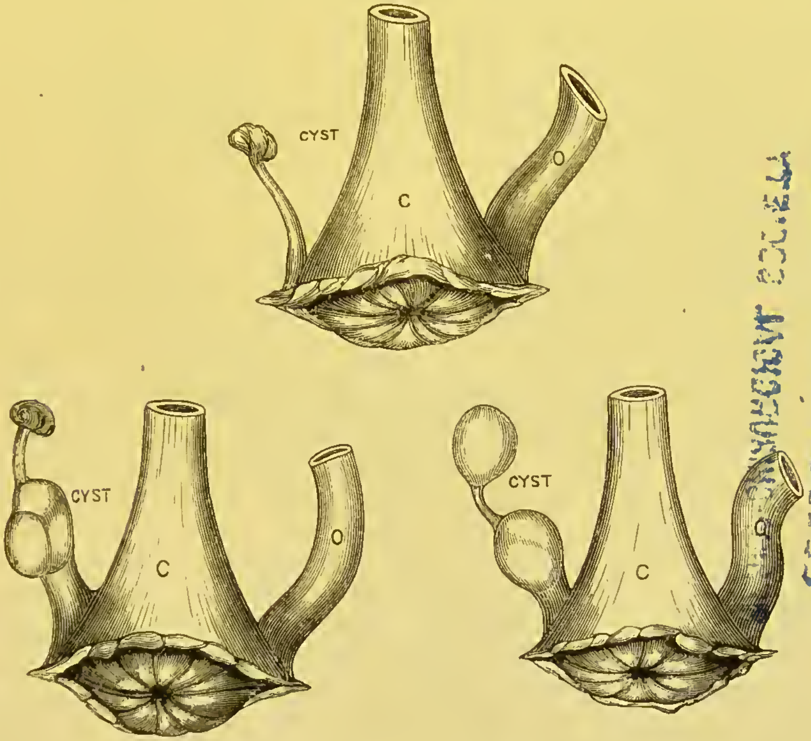

Fig. 84.—Various Stages of Cystic Rudimentary Oviducts in Birds.

O, the functional oviduct cut short. C, cloaca.

in albumen. In the third portion of the tube the shell is formed. The mucous membrane of this, the uterine portion, contains some follicular glands, which secrete a thick white fluid; this coats the egg, and serves as a nidus for the inorganic particles which ultimately form the shell.

The transit probably occupies, on an average, twenty to twenty-four hours, of which more than three-fourths are spent in the uterine portion of the oviduct.

In the first place, some abnormal conditions of the rudimentary right oviduct will demand attention. From what has been stated concerning frogs and toads, it will, of course, not surprise us to find that the remains of the Müllerian duct of the right side should occasionally be found in a cystic condition.

Such is, indeed, the case, especially in the common forms of domesticated poultry. The various stages of dilated rudimentary oviducts are shown in Fig. 84. The usual condition of the rudiment, when present, is shown in the highest figure, whilst the lower ones represent them in a fully cystic condition. These cysts are occasionally a source of danger to birds; they may rupture, and give rise to fatal inflammation of the peritoneum.

It is necessary to exhibit care in examining specimens of supposed persistence of the right oviduct, so as not to confound them with a persistent vas deferens, which occasionally is found in birds the subjects of lateral hermaphroditism. Sir James Simpson, in his famous article on hermaphroditism,* records two cases which he met with in domestic fowls. In each case the functional female organs, ovary and oviduct, were on the left side, as usual; but on the right side a vas deferens, of about half the normal length, ascended in the mesometrium. No vestige of a testicle could be discovered. In both cases the birds possessed, in an imperfect degree, the plumage, comb, spurs, and general appearance of a cock. Both birds regularly laid eggs, but were never known to incubate; and though attempts were repeatedly made to hatch the eggs, they were on all occasions unsuccessful.

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* "Collected Papers," vol. ii., p. 437.

In many museums, specimens of the oviduct of fowls are preserved, showing great distension, due to the accumulation in their interior of material arranged in distinct laminæ. Such are usually described as tumours; but they are cases where, from some cause, frequently stricture of the oviduct, the eggs are prevented from entering the lower parts of the duct. Thus, successive eggs become fused into a laminated mass, giving rise to the mistaken notion of a tumour.

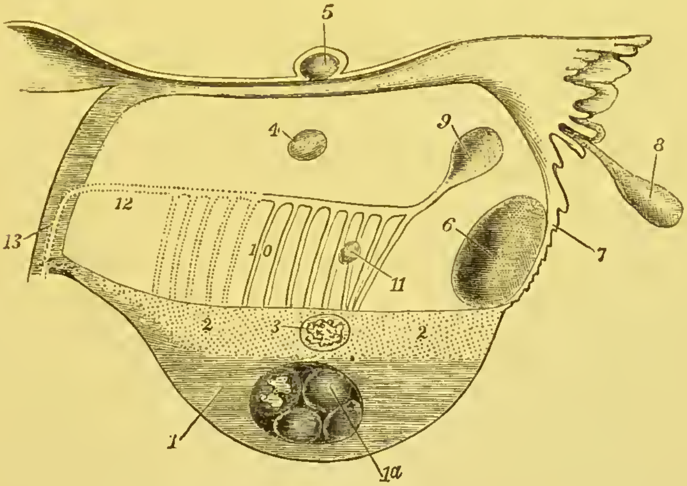

Fig. 85.

1. Oophoron, the seat of simple and glandular cysts arising in Graafian follicles and corpora lutea. 2, 3. Paroophoron, the seat of papillomatous cysts. 4, 5, 6. Broad ligament cysts (lymphatic ?). 8. Hydatid of Morgagni. 10. Parovarium. 12, 13. Duct of the mesonephros (Gartner's).

(Drawing from Doran, but the references are in accordance with the terminology of this work.)

In transverse section such a mass has rather the appearance of a consolidated aneurism than of a tumour.*

The above figure represents, in a diagrammatic way, the various structures in which cysts connected with the female reproductive organs arise.

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* For further information concerning diseases of the reproductive organs in birds, see "Journal of Anatomy and Physiology," vol. xix., p. 121, and "Path. Soc. Trans.," vol. xxxvi., p. 499.

CYSTOMATA IN CONNECTION WITH THE MALE REPRODUCTIVE ORGANS.

Cysts occurring in the male generative organs are few, and may be classified as follows:—

(1) Hydrocele—(*a*) of the tunica vaginalis; (*b*) funicular hydrocele; hæmatocele.

(2) Cysts of the paradidymis. This variety is often termed encysted hydrocele.

(3) Dilatation of the utriculus masculinus.

Hydrocele.—In many animals—fish, lizards, crocodiles, snakes, and birds—the testicles normally lie in the abdominal cavity, in close relation with the kidney. In other forms they descend from this position, in the pairing season, and temporarily occupy the scrotum, to be drawn again into the abdomen when that season ends. In other forms, including horses, dogs, lions, tigers, cats, bears, and man, they permanently occupy the scrotum, being partially invested by a double layer of the peritoneal diverticulum, known as the funicular pouch. The interior of this pouch is usually cut off, after birth, from its former communication with the peritoneum. This pouch often becomes the seat of a serous effusion; it is then termed a hydrocele. It is usual for all that portion of the serous sac lying between the top of the testis and the inguinal ring to become obliterated; but occasionally spaces exist here and there, which form cavities filled with serous fluid. These are known as hydroceles of the spermatic cord. A similar condition is at times associated with the serous pouch accompanying the round ligament of the uterus: this is spoken of as hydrocele of the round ligament.

If from any cause, traumatic or otherwise, blood becomes extravasated into the sacs, they are then called hæmatoceles. The etymology is obvious. Hydroceles undergo certain changes with age: the fluid may undergo absorption—this is very rare; the walls may undergo fibrous thickening, or become calcified and acquire a great thickness. These cysts occur in monkeys, horses, dogs, and bulls.

Encysted Hydrocele.—This is the most interesting form of hydrocele, in so far as its pathology is concerned. Various views have been held from time to time regarding the structures in which this form of cyst arises. The condition is somewhat complicated by the circumstance that these cysts contain seminal fluid. This has led many pathologists and surgeons to regard them as arising in dilatations of the seminiferous tubules. The more probable view, however, is the one that refers them to dilatation of remains of the Wolffian body, or paradidymis (the organ of Giraldès), which may be found between the epididymis and the testicle. If this be compared with what we know concerning the remains of the Wolffian body and the parovarium in the female, and remembering that the vasa efferentia are really the parovarian tubules in a functional condition, we should not feel surprise that cysts arise in this situation. The presence of spermatozoa in them may be explained by the fact that the transverse tubules of the mesonephros, when applied to the testicle, become the excretory ducts of this organ, and are therefore in the best possible condition to contain spermatozoa or seminal fluid. Those who imagine that these cysts arise in a vas aberrans may be reconciled by the statement that this structure is a detached tubule, originally belonging to the tubular system of the mesonephros. The largest example of this form of cyst known to me is an admirable specimen in the museum of the Royal College of Surgeons, which is described in the catalogue as a testicle with a large multilocular cyst with very thin walls attached near the epididymis, in the position where the organ of Giraldès, or remains of the Wolffian body is found. The loculi are separated from each other by thin partitions, and have no definite arrangement. They contain a transparent watery fluid, in which no spermatozoa could be found.

Dilatation of the utriculus masculinus occurs in man as a sequel to stricture of the urethra. The condition is very frequently overlooked.

CHAPTER XIV.

SPURIOUS CYSTS.

Cavities often arise in the substance of solid organs and tumours as the result of hæmorrhage, softening, or disintegration of their tissues. Such spaces are commonly called cysts, but their mode of origin is so different from the true cystomata that the adjective spurious is well applied to them.

When foreign bodies or parasites lodge in the tissues, their presence excites inflammation in their immediate vicinity; the inflammatory products organize into fibrous tissue, which forms a cyst-wall around the offending body. Such cavities as these are included under the term spurious cysts. Abnormal dilatation of arteries and bronchi due to disease of their walls, and false diverticula due to hernia of the mucous membrane, also come in the same category.

For convenience of description, spurious cysts will be arranged in five groups:

(1) Diverticula—(*a*) intestinal; (*b*) pharyngeal; (*c*) arterial; (*d*) venous; (*e*) synovial; (*f*) vesical; (*g*) retro-tracheal.

(2) Dilatations—(*a*) arterial; (*b*) bronchial.

(3) Softening in new growths.

(4) Extravasation of blood and serum—(*a*) hæmatocele; (*b*) hydrocele; (*c*) dropsy.

(5) Parasitic—*e.g.*, hydatids, cysticerci, Tænia cœnurus, etc.

Diverticula.—The term diverticulum is used to denote hernia, or protrusion, of the lining membrane of a cavity through a defective spot in its walls. If in the intestines or bladder, the projection will force its way between the muscular fasciculi; in the case of synovial membranes, through the capsule of the joint or sheath of the tendon. In the case of the walls of blood-vessels, the protrusion may make its way through a defective spot in the tunica adventitia.

Intestinal Diverticula.—These are simply hernial protrusions of the mucous membrane through the muscular coat of the bowel. In structure they are composed simply of mucous membrane and peritoneum. They are frequently multiple; as many as two hundred have been counted in one case. They are far more frequently multiple than single. They are found in all parts of the intestine, but are most frequent in the colon, especially about the sigmoid flexure. In the small intestines they usually occur along the line of attachment of the mesentery. In the colon they are found about the attachment of the appendices epiploicæ, and may even project into them.

In dimensions, these diverticula may vary in size from a pin's head to that of an orange. If many cysts are present, they are usually of small size; when single, they may be of large dimensions. They are of most frequent occurrence in the old, and rarely lead to any serious consequences.

For all that concerns these diverticula, read the admirable account in Treves' "Intestinal Obstruction," 1884.

Pharynx and Œsophagus.—Diverticula agreeing in character with those last described occur in the pharynx and œsophagus, often attaining a remarkable size. Although cysts of the œsophagus of this character are frequently associated with mechanical impediment, nevertheless this association is often wanting.

Morrison Watson, in the "Journal of Anatomy and Physiology," vol. ix., p. 134, described a most extraordinary diverticulum from the pharynx.

For an interesting example of an œsophageal diverticulum occurring in a bird, see Fig. 87, p. 229.

Diverticula of the œsophagus and pharynx arising in this manner must be carefully distinguished from congenital defects in these tubes.

Aneurism and Varix.—If from any cause the outer tunic of an artery or vein becomes weakened or destroyed either by inflammation, suppuration, or from traumatic causes, the inner coats will protrude through the defective spot, and form a cystic swelling, termed, in the case of an artery, aneurism; and if it affects a vein it is called a varix.

Aneurisms and varices may, however, arise by other modes, and it is impossible in a work of this kind to do more than mention them.

Ganglia.—A ganglion may be defined as a localized swelling of the sheath of a tendon, or the synovial membrane of a joint. There are two forms, simple and compound.

Simple.—These may arise either as a hernial bulging of the synovial membrane through a rupture in the tendon sheath, the result of strain, or the continued friction of the tendon leads to thinning of its connective tissue sheath, allowing the synovial membrane to bulge unduly on account of abnormal accumulation of fluid; sometimes, however, they result from inflammation.

It occasionally happens that a diverticulum starting in this way from a tendon sheath may become pedunculated, and the funicular process eventually gets occluded and the ganglion shut off from its connection with the sheath. In the same way the synovial membrane of a joint, either in consequence of a strain or inflammation (synovitis), may lead to undue distension of its serous membrane, resulting in local diverticula passing between the surrounding structures, simulating ganglia and bursæ. These may retain their connection with the joint, or become eventually separated from it. In this way synovial diverticula and cysts, often of large size, arise.* Ganglia are common in man, and are exceptionally frequent in horses.

Compound Ganglia.—If the inner wall of a ganglion inflame, lymph is exuded on the surface, and the constant friction rolls and fashions the soft lymph into little pellets known as melon-seed bodies. When these are present, the ganglion is said to be compound. The little bodies may occasionally arise in consequence of calcification and subsequent detachment of the villous processes which commonly beset the synovial membranes of joints and tendons. In man, compound ganglia are more especially seen in connection with the extensor tendons of the forearm at the wrist.

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* For all that concerns synovial cysts arising from joints, consult Morrant Baker's papers in "St. Barth. Hosp. Reps.," vols. xiii. and xxi.

Bladder.—The sacculations of the bladder, which are of such frequent occurrence in man, belong to the same group; they simply consist of a hernial protrusion of the mucous membrane between the muscular fasciculi. The cause of this protrusion is impediment to the free flow of urine, due either to causes arising in the urethra or at the neck of the bladder. In some cases a sacculation arising in this way may attain such proportions as to rival, or even exceed, those of the bladder. The saccules may be multiple or single, but more frequently several saccules may be detected in the same case. There can be little doubt that some cases described as sacculated bladders, and some few instances of so-called bifid bladders, were really instances of allantoic cysts (see p. 181).

Retro-tracheal Cysts.—Rokitansky appears to have been the first writer to direct attention to the occurrence of these cysts, which he correctly describes as a saccular or hernial protrusion of the tracheal mucous membrane due to relaxation of the posterior wall of the trachea. The condition, he writes, is dependent on repeated chronic catarrhs of the trachea, and forms one of a number of analogous cases occurring in other parts of the body.

Gruber regards the cysts as belonging to the class of retention-cysts, believing them to arise from retention of the secretions of the mucous glands. This may be so, but it is much more probable that they arise in the way indicated by Rokitansky.

Chief References.

Rokitansky : "Ueber die divertickel-ähnliche Erweiterung des Luftröhrenkanals." "Oesterr. Med. Jahr.," Bd. xxv., S. 382. Wien, 1838.

Wenzel Gruber: "Ueber ein retrotracheales Retention Geschwulst." "Virchow's Archiv," Bd. xlvii. und Bd. lxv.

Virchow: "Die krankhaften Geschwülste," Bd. i., S. 231, 233, 246.

The most remarkable example of tracheal cysts known to me, is the one associated with the trachea of the emu, which will be considered in detail.

The Tracheal Pouch of the Emu.

If the skin and tissues be reflected from the front of the neck of an emu, *Dromæus Novæ-Hollandiæ*, the dissector will find that on cutting into the subcutaneous tissues he will suddenly enter a large cystic chamber, such as is represented in Fig. 86. Occupying the posterior wall of the cavity is the trachea, which presents a curious deficiency in about six of its rings, situated somewhere between the fiftieth and sixty-fifth rings, resembling a window. The precise rings affected are liable to slight variation. In the case from which Dr. Murie's figure was taken, the cyst was fourteen and a half inches long, and three in width. The opening by which the cyst communicated with the trachea was two and three-quarters inches long, and in the retracted condition the slit measured 0·3 inch transversely, but when stretched it became very much wider. The cyst-wall is composed of white elastic tissue, overlaid externally with thin scattered bundles of striated muscle-fibres; internally it is lined with mucous membrane dotted with mucous glands. If the cyst-wall be carefully traced, it will be found to become continuous with the mucous membrane lining the interior of the trachea. From an examination of the adult bird, it is easy to convince oneself that the sac may be regarded as a hernial protrusion of the tracheal mucous membrane through a deficiency in the anterior wall of the trachea. Such is really the case. Dr. Murie showed ("Proc. Zool. Soc.," p. 408, 1867) that in the young bird the sac is very small, and only to be detected by inflating it. By good fortune, an emu chick, a few weeks old, recently came into my hands, and no trace of a cyst could be detected, and the tracheal window was represented by a mere slit. It is easy to see that the course of events is as follows :—

In the emu there is a natural defect in the trachea, at a spot varying in position between the fiftieth and sixty-fifth rings. As the bird grows, the tracheal mucous membrane becomes gradually herniated through the deficiency, until a huge saccular diverticulum is formed. During the breeding season the birds inflate the cyst with air, and they are then

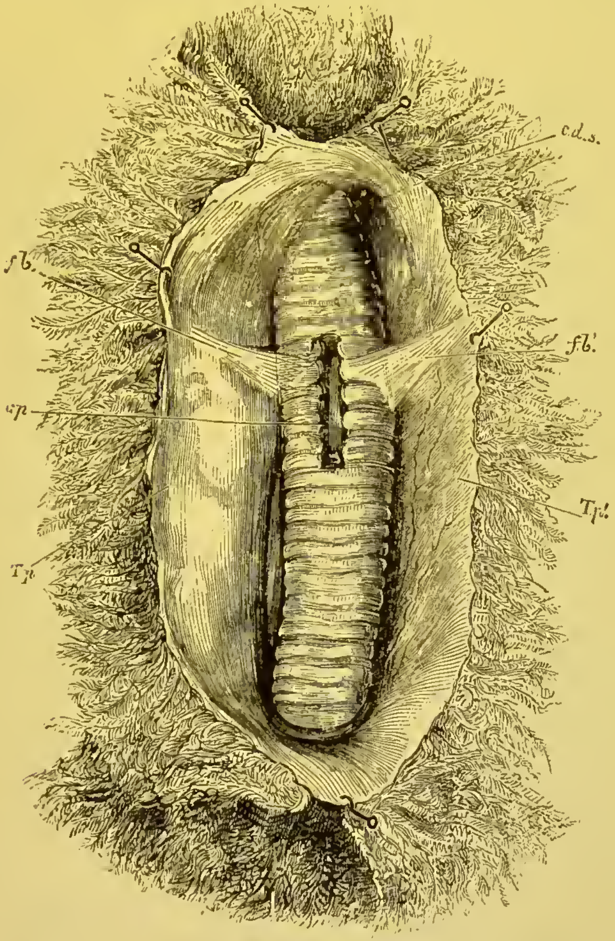

FIG. 86.—TRACHEAL POUCH OF EMU. (After Murie.)

The feathers have been cut short. *ap.*, aperture in the trachea due to deficiency in the tracheal rings. *f.b.*, fibrous bands passing across the sac.

able to produce the peculiar drumming sound, which resembles the noise made by blowing across the neck of a bottle. For many curious suggestions regarding the probable use of the sac, as well as for an admirable *résumé* of the anatomy and accounts of this tracheal cyst, the reader should consult Dr. Murie's excellent paper in "Proc. Zool. Soc.," 1867, p. 405. My attention was forcibly drawn to this cyst in consequence of an emu having been killed in an attempt to relieve the cyst of an enormous accumulation of mucus which it contained, as a result of inflammation. The case is fully reported in the "Journal of Anatomy and Physiology," vol. xx.

In that paper, evidence has been brought forward and arguments advanced in favour of the view, that in this case we have to deal with an abnormal structure which has been brought about by pathological conditions, and the defect in the trachea having been transmitted to the offspring, the diverticulum of the mucous membrane is a necessary consequence, and has become transmitted as a race peculiarity.

The Gular Pouch of the Bustard.—During the sexual season it has long been known that the male bustard, *Otis tarda*, exhibits the peculiar phenomenon known as the "showing off," that is, the bird distends its neck to an enormous extent, and displays itself by strutting up and down in front of the female. It has been a disputed point among those anatomists who have interested themselves in the question, to what is this distension due? Some have asserted it to depend on dilatation of the œsophagus; others ascribe it to a curious cyst occasionally found in front of the œsophagus.

On dissecting the neck of a male of *Otis tarda*, a cyst, such as is shown in Fig. 87, will often be found lying in front of the œsophagus. This cyst opens through the middle of the frænum linguæ: it is important to note, however, that this cyst is not always present, and competent authorities have failed to detect it in birds which have been known to go through the performance of "showing off."

The Australian bustard, *Eupodotis Australis*, also displays itself by "showing off" in the same way as *Otis tarda;* in this instance there is no gular pouch, but the œsophagus is as capable of dilatation as in a pouter pigeon.

If the gular pouch is not essential for the "showing off," how can its presence be explained? Garrod, in two very interesting papers on this subject, published in the "Proc. Zool. Soc.," 1874, pp. 471, 673, points out that there is every reason to believe that the gular pouch in *Otis tarda* is produced as a hernia of the sublingual mucous membrane between the two portions of the frænum linguæ, as a result of the pressure exerted on the parts when they are inflated.

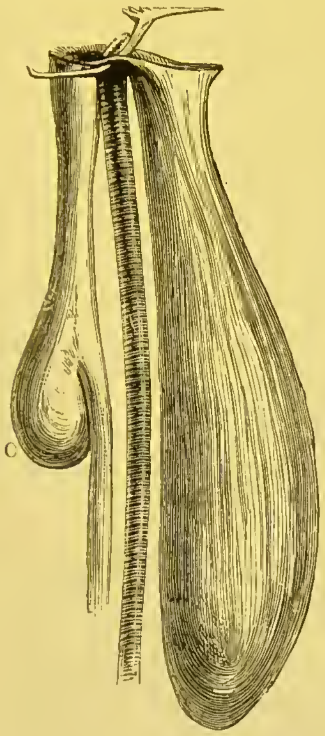

FIG. 87.—GULAR POUCH OF THE BUSTARD, *OTIS TARDA.* (After Garrod.)

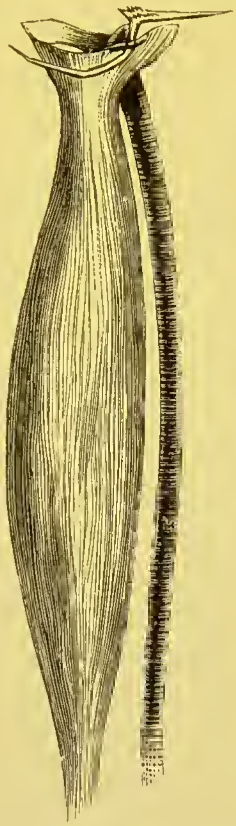

FIG. 88.—DILATED ŒSOPHAGUS OF THE AUSTRALIAN BUSTARD, *EUPODOTIS AUSTRALIS.* (After Garrod.) There is no trace of a pouch or crop.

This view is rendered probable by the fact that the pouching of the œsophagus, c, in Fig. 87, which resembles a crop, is really a diverticulum of the œsophagus, and is probably produced in the same way as the sublingual or gular pouch.

Mr. Forbes, in a communication to the Zoological Society on the anatomy of the Australian duck, *Biziura Australis*, pointed out the existence of a double frænum in this bird, and the association with it of a sublingual pouch similar to, but smaller than, that found in the bustard ("Proc. Zool. Soc.," 1882, p. 455).

These facts seem to indicate clearly enough that the sublingual pouch is really a hernia of the mucous membrane, brought about in much the same way as multiple diverticula in the intestine, or sacculations of the bladder, or a diverticulum from the œsophagus. In the case of the bustard the tendency is inherited, inasmuch as the frænum linguæ is bifid; and it seems to me that in the cases of the emu and bustard we have parallel instances, and the same argument as to the hereditary nature and transmission of the defect applies to the bustard as well as to the emu.

Dilatations.—This group will not be considered in any detail; but under this heading may be included dilatations of such tubes as arteries, forming the so-called true aneurism. Veins dilate in various parts of their course when impediments arise to the free flow of blood. These dilatations should be spoken of as varicosities in order to distinguish them from true varix.

In the brain the capillaries are very prone to dilate, especially in old people, forming the *miliary* aneurisms described by Professor Charcot.

To this group belong also the dilatations of the bronchial tubes constituting bronchiectasis, which is frequent in certain chronic diseases of the respiratory organs. Bronchiectasis is in rare instances met with as a congenital affection.

Cysts from Softening.—In various tumours to which animals are liable, spaces often exist filled with fluid more diffluent in character than the elements which are characteristic of the tumour. Thus certain secondary changes, such as mucoid or colloid degeneration, may produce this result, or an extravasation of blood may occur in the substance of a neoplasm, or even into the healthy tissues under tense membranes, constituting hæmatomata. To such spaces as these the name cysts has been unfortunately applied. False cysts of this kind are often seen in the brain of old people, due to the absorption of an old clot, the residue of cerebral hæmorrhage.

Parasitic Cysts.—This variety includes the cysts, frequently of large size, which are formed by hydatids, and the various kinds of cysticerci, etc., which infest animals and man.

For a detailed account of the mode by which parasites and foreign substances become encysted in animal bodies, reference should be made to the chapter on "Interstitial Inflammation," page 129.

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CHAPTER XV.

CONGENITAL CERVICAL CYSTS.

These cysts are often referred to as hydrocele of the neck, or congenital cervical hygromata. Their general appearance may be inferred from the specimens represented in Figs. 89 and 90.

The chief facts connected with their anatomy are the following :—

They have a preference for the carotid triangle, and are very frequently situated near the middle line of the neck. The tumour may be, and often is, polycystic.

Mr. T. Smith,* who has had unusual opportunities of studying these cysts, asserts that when they occur near the middle line of the neck they are always beneath the deep cervical fascia, although many of them may have a subcutaneous portion. Mr. Holmes† supports this statement, and further asserts that the subcutaneous or superficial portion makes its way through the deep fascia by pressure.

The invariable situation of these congenital cysts beneath the deep cervical fascia is a very important fact in their anatomy, and it will be well, before proceeding further, to refresh the memory with the main facts in the arrangement of this complex sheet of fascia, and then proceed to compare it with peculiarities in the necks of other animals.

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* Mr. T. Smith : "St. Barth. Hosp. Rep.," vol. ii.

† Holmes and Hulke : "System of Surgery," vol. iii., p. 882.

The Deep Cervical Fascia.—The deep cervical fascia, with all the intricate infoldings it is made to assume by purely *human* anatomists, is a mysterious structure to the student, yet when viewed in its true aspect becomes very interesting. The chief points for our purpose in its relation to cervical cysts are briefly these:—It is a very strong fascia lying beneath the platysma muscle. It has firm attachments to the hyoid bone, and blends with the fascia covering the masseter and sterno-mastoid muscles. Below, it gains a strong attachment to the clavicle, but is directly continuous with the costo-coracoid membrane, and by means of this structure becomes one sheet with the axillary fascia. Near the middle line of the neck a prolongation of the fascia passes behind the manubrium sterni, and enters the mediastinum to become continuous with the fibrous layer of the pericardium. The various infoldings among the muscles, vessels, nerves, etc., are of no interest; they serve to confuse rather than instruct.

If we examine the relations of this fascia in certain monkeys, especially in an adult chimpanzee, orang, or a howling monkey, we shall find that on cutting through the deep cervical fascia we have entered into an enormous subfascial chamber, which communicates with the larynx above, extends in the middle line to an inch behind the manubrium sterni, and laterally into each axilla, the axillary fascia forming its lowest limit. In one fine specimen of chimpanzee I injected this huge reservoir, and found it to hold three pints of injection material. In some animals, especially the howling monkey, *Mycetes*, the air-sacs are relatively larger than in other monkeys, and in many the basihyal is hollowed out into an air-chamber. These cervical air-sacs exist in many animals, and can be inflated according to will. It is probable that they are used in enabling these animals, especially the howling monkeys, to utter shrill notes.

These air-chambers arise as diverticula from the larynx, either from the sacculus laryngis on each side, or from the pouch of Morgagni in the middle line of the larynx, immediately below the epiglottis; they project through the thyro-hyoid membrane, and undermine the cervical fascia. If Morgagni's pouch alone dilates, a single median sac results; if the sacculus laryngis, then two lateral sacs are represented. In the chimpanzee the sacs arise in the three situations, and eventually meet; the dividing walls disappear, and one huge chamber is the result. The museum of the Royal College of Surgeons contains some excellent dissected examples of the chief varieties of the cervical sacculi in many animals.

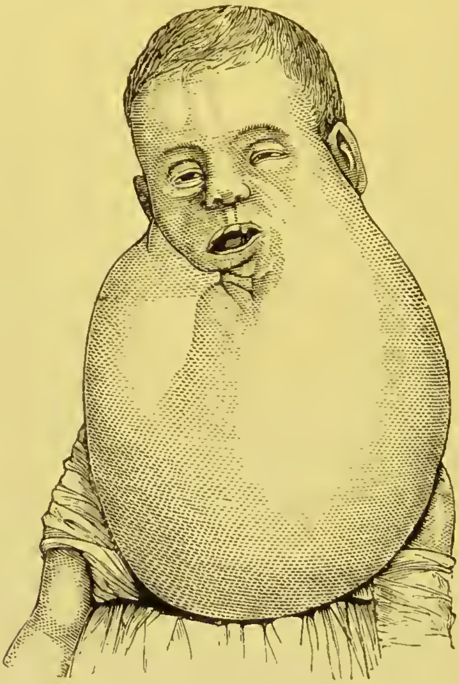

FIG. 89.—CONGENITAL CERVICAL CYST. (After Treves.)

In Mr. Treves'* case, represented in Fig. 89, the dissection absolutely demonstrated the relation of the cysts to the larynx and to the hyoid bone. The relations of the cyst corresponded with the arrangement of the deep cervical fascia above the clavicle. The careful account of the dissection in this valuable case is very instructive. But the cases which to my mind are the most conclusive in proving that these cervical cysts are due to distension with fluid of similar saccules, arising as aberrations in the human subject, are two

* "Path. Soc. Trans.," vol. xxxii., p. 194.

very excellent instances reported by Mr. T. Smith,* in which the cysts existed in the usual situation in the neck, and extended thence into the axilla (Fig. 90). Mr. Birkett relates three cases of this nature in the "Med.-Chir. Trans.," vol. li., p. 185, and gives admirable figures of a patient whom he operated upon, a man, aged twenty, in whom the cyst extended into the axilla, like that in Fig. 90.

Mr. Jonathan Hutchinson has figured some exquisite examples of these congenital cervical cysts in his "Illustrations of Clinical Surgery," vol. i., p. 35. One of the cases is especially interesting, for the cyst followed the median portion of the cervical fascia and passed behind the manubrium sterni into the superior mediastinum.

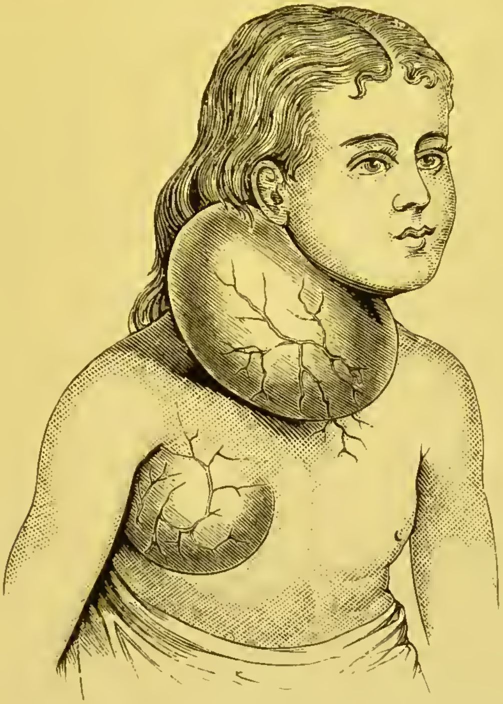

FIG. 90.—A CONGENITAL CERVICAL CYST. (After T. Smith.)

The reasons for believing that congenital cervical cysts are o be regarded as of the nature of laryngeal saccules may be summarized thus:—

(1) The congenital nature of the cysts. Repetitions of animal structures of this kind are always congenital.

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* "Clin. Soc. Trans.," vol. xiii., p. 197.

(2) Their relation to the hyoid bone and larynx. The hollow on the back of the basi-hyal is a representative, in a minor degree, of the large cavity in this bone of some animals.

(3) The situation of the cysts beneath the deep cervical fascia, and their occasional extension into the axilla.

It must also be borne in mind that very many congenital cysts in the neck are not simple, but vary in their composition until they come in the category of teratomata. For an account of this variety, see chapters xx., xxi.

Mr. Hutchinson* has recorded examples of cysts hanging from the sides of the chest near the axilla in children. From the excellent drawings and careful description given of the cases, it seems probable that the cysts originated in the axilla, as in the case of ordinary congenital cervical cysts, and later became pedunculated, this serving to disguise their true nature.

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* "Illustrations of Clin. Surgery," fas. xii., plate xliv.

SECTION IV.

CHAPTER XVI.

NEOPLASMS.

THE term tumour has been applied to so many kinds of growths, and used so loosely, especially in clinical work, that it ceases to carry with it any definite significance. It is necessary to adopt some rigorous limitation to the term, or choose a name which shall enable us to discriminate between "true" tumours and the curious medley with which by the majority of writers they are confounded.

A neoplasm may be defined as *a new growth, characterized by histological diversity from the matrix in which it grows. It is distinguished from inflammatory new formations by the variety of its forms, mode of origin, and the frequent inherent tendency it has to increase.**

This definition excludes hyperplasia of organs, and the infective granulomata, such as glanders, farcy, tubercle, perlsucht, actinomycosis, the lesions of syphilis, and the like.

With regard to the histological diversity exhibited by a neoplasm, it should be mentioned that it may more or less resemble the matrix tissue, but certain features may always be detected whereby we are able to demonstrate its heteroplastic nature.

This question will be fully dealt with in the sections appropriated to individual varieties of neoplasms.

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* The term tumour is so deeply rooted in medical literature, that as a clinical term it would be unwise to attempt to discard it; but it is absolutely necessary to distinguish between a tumour and a neoplasm in studying pathology.

Neoplasms, though more prone to occur at certain spots than at others, may be met with in any organ or tissue of the body. Among animals the commonest places for tumours are the bones, anus, mammary glands, orbits, mouth, and subcutaneous tissues in all regions of the body. As, in man, certain forms exhibit a great tendency to reproduce themselves in distant organs, and to recur after removal, such are termed *malignant*. Frequent situations for these secondary deposits are the liver, spleen, lungs, and abdominal lymphatic glands.

Other neoplasms never show this malignant tendency, only becoming dangerous by their bulk or situation interfering with the functions of important organs. As a rule they are separated by a layer of neutral tissue from the surrounding structures; hence they are said to be *encapsuled*. If they grow from the walls of a cavity, or near one of the natural openings of the body, such a tumour has a tendency to become stalked or pedunculated; it is then termed a *polypus*. Many of the malignant growths diffuse themselves through the organ or tissue in which they originate, and, lacking a definite capsule, are said to be *infiltrating*.

The following statements apply to all neoplasms:—They are, for the most part, solitary, but may be multiple. They are very liable to retrogressive changes—fatty, mucoid, calcareous, or pigmentary,—hence they may soften, liquefy, and form spurious cysts. They often ulcerate and, if their nutrition is interfered with, suffer necrosis. There is no limit to their growth, so that under favourable conditions they may attain considerable dimensions. Morbid growths exhibit a strong tendency to attack functionless or abnormal organs, such as pigmented moles, undescended testes, scars (especially those the result of burns), eyes rendered useless by disease, nævi, and chronic ulcers of the integument. Dissemination of the growth is effected by two channels, either by the blood-vessels or by the lymphatics, in some cases by both.

Neoplasms, even the most malignant, transplanted experimentally into healthy tissues fail to grow, and we have little reliable evidence as to their capability of inoculation; nevertheless, there is good reason to believe that the so-called metastases of malignant growths are due to portions of the primary growth being directly conveyed by the blood or lymph stream, and lodged in distant regions of the body.

Classification.—The most scientific basis on which to found a classification of neoplasms is undoubtedly an embryological one, leaving the histological details to determine the varieties. In this way they are divided into three great classes—those arising from tissues mesoblastic in origin, those containing tissues formed from the epiblast and hypoblast, and those composed of tissues derived from the three embryonic layers. This arrangement is by far the most satisfactory that has as yet been proposed, and will be strictly adhered to throughout this section.

It will perhaps be convenient to briefly summarize the more important organs derived from each of the three germinal layers.

(1) *Epiblast.*—This layer gives rise to the central nervous system and the epidermis (the dermis is of mesoblastic origin so that the line of junction between the epiblast and mesoblast is indicated by that between dermis and epidermis). The tegumentary organs and the lens. The peripheral and sympathetic nervous systems. The retina, including the pigmentary layer. The epithelial expansions of the membranous labyrinth, and the lining membrane of the nasal fossæ. The cavity of the mouth and anus, including the glands peculiar to these cavities and the pituitary body.

(2) *Hypoblast.*—From this layer the epithelium of the digestive canal, trachea, bronchia, and air-cells is derived. The epithelium of the ducts of the liver, the pancreas, thyroid body, the other glands of the alimentary canal, and the hepatic cells. The lining of the allantois is of hypoblastic origin, and probably the notochord.

Also the epithelium covering the peritoneum and pleura, and the epithelial elements of the generative and urinary organs (*see* chapter xix. p. 313.)

(3) *Mesoblast.*—The muscles, the bones, connective tissues,

and vessels, including arteries, veins, capillaries, lymphatics, and their lining epithelium, are derived from this layer. It must be borne in mind that the connective tissue, vascular and muscular elements of epiblastic and hypoblastic structures, are derived from the mesoblast.

This mode of classification is further sanctioned by the law known as the *specific nature of tissues.* For example, the cells of the epiblast never produce bone, neither do the cells of the mesoblast give rise to epithelium, and this specific character of the tissues arising from the three embryonic layers is maintained throughout the whole of life. Careful researches confirm this law.

The following table gives the arrangement of neoplasms according to the embryological plan. Each group will be dealt with separately, in the order of the table. The subdivisions will be made when each group is considered.

Mesoblastic Group.

Connective Tissue Neoplasms.

1. Fibromata.
2. Myxomata.
3. Lipomata.
4. Enchondromata.
5. Osteomata.
6. Odontomata.
7. Angiomata.
8. Myomata.
9. Neuromata.
10. Sarcomata.

Epiblastic and Hypoblastic Group.

Epithelial Neoplasms.

1. Adenomata. 2. Carcinomata. 3. Papillomata.

Epiblastic, Hypoblastic, and Mesoblastic Group.

Teratomata.

THE MESOBLASTIC GROUP.

Fibromata.—Fibromata agree in structural details with fibrous tissue. In consistence they vary much, in some instances being hard, dense, and creaking under the knife; at other times they are soft, and present a greyish translucency. The softer forms are rich in slender cells, either fusiform or caudate. The tougher examples are made up of bundles of wavy fibrous tissue, presenting a peculiar whorled appearance containing few cells. In man these tumours may occur in any organ or structure which contains connective tissue. In animals the most common situation is the subcutaneous connective and submucous tissues.

The museum of the Royal College of Surgeons contains several specimens of this nature removed from animals. The following cases are selected from the catalogue:—

The first specimen is a cluster of fibromata, mostly globular in form, varying in size from half an inch to three inches in diameter, growing in or beneath the mucous membrane of the stomach of an ox, and projecting into its cavity. On section they present a uniform greyish-white colour, with numerous paler, wavy, fibrous bands intersecting each other, like those seen in fibro-myomata of the uterus.

The second was taken from a cod-fish. It lay in the loose tissue beneath the skin in the abdominal region. This growth presents an interesting feature, for it had undergone calcification, thus showing that in animals secondary changes take place, as in similar tumours occurring in man.

The third represents a fibroma taken from the stomach of a cod-fish, where it had apparently originated in the submucous areolar tissue. Its section shows a homogeneous basis of a pale grey colour, intersected in various directions by curving bundles of white, glistening fibrous tissue.

The fourth is also from the stomach of a cod-fish. It is of oval form, and measures nine inches in the major, and five inches in the minor axis. It appears to have grown between the coats of the stomach. In structure it corresponds with the growths previously described (Fig. 91). The museum contains a fifth example, springing from the psalterium of the stomach of an ox. It is deeply lobulated and of considerable size, being attached by a small pedicle, and composed of reticulated fibrous tissue.

The sixth occurred in a variegated rat. The entire animal is preserved in the museum. Lying immediately beneath the skin of the neck, and entirely confined to the cellular tissue, is an enormous tumour, compared with the size of the animal, measuring three inches in its longest diameter (Fig. 92). Histologically, it is composed of coarse fibrous tissue. Virchow* figures a unique example of numerous fibrous pedunculated growths attached to the interior of the gall-bladder of a cow, giving it a villous aspect. Horses are liable to fibromata, especially in the neighbourhood of the scapulæ.

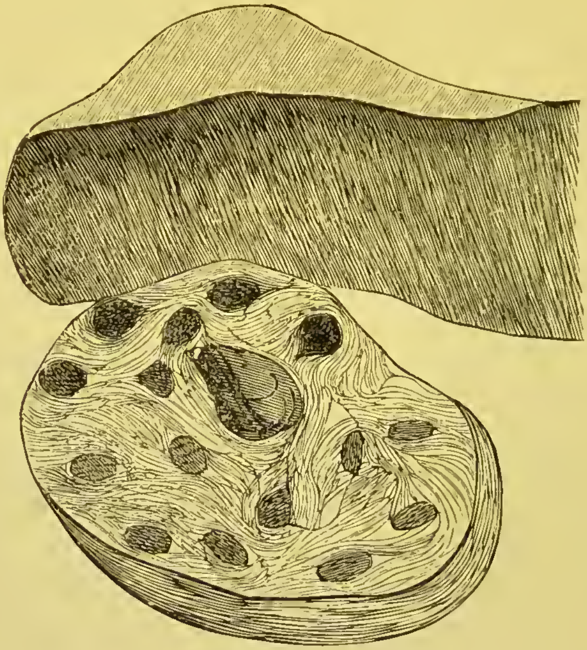

Fig. 91.—A Fibroma attached to the Stomach of a Cod-fish (reduced to one-fifth its actual size).

It must be borne in mind that all fibrous neoplasms may not have been composed of fibrous tissue originally, but may have consisted in great part of unstriped muscle-fibre, which has later degenerated into fibrous tissue. The growths of the stomach of the ox and cod-fish appear to be of this nature; that of the rat is a genuine fibroma. It has long been recognized that muscles little used or paralysed do, after a time, become wholly represented by a mass of fibrous tissue, and the same change certainly affects the non-striated variety of muscle-fibre.

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* "Pathologie des Tumeurs" tom. i., p. 337.

The following case, recently described by M. Cadéac in the "Recueil de Médecine Vétérinaire," March 15, 1885, seems to support my view concerning fibromata attached to the alimentary canal. A tumour, about the size of a child's head, was found on the duodenum of a mare which had died from rupture of the stomach, caused by the growth. The morbid mass was hard, resistant, of a greyish-white colour, and enveloped the stomach like a muff, and so narrowed the lumen of the viscus that it only measured two and a half centimetres at this spot. Histologically examined, the growth was found to be a fibro-myoma composed of undulating wavy fasciculi, each fasciculus containing fusiform cells with a distinct and elongated nucleus. In parts the neoplasm showed areas of fatty degeneration.

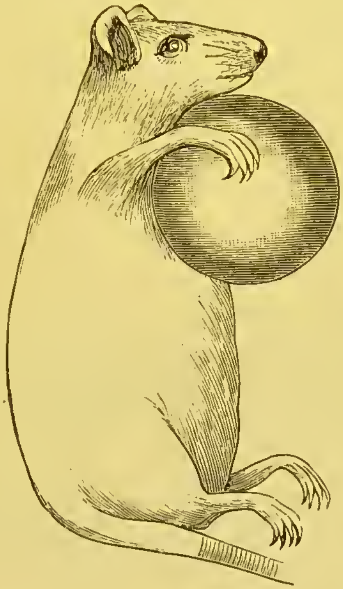

FIG. 92.—A VARIEGATED RAT WITH A FIBROMA GROWING FROM THE SUBCUTANEOUS CONNECTIVE TISSUE IN THE FRONT OF THE NECK.

This case is important, in that it demonstrates clearly enough that fibro-myomata grow in connection with the alimentary canal. A glance at Fig. 91 is sufficient to show that in the peculiarly whorled appearance presented by that tumour we have a repetition of the characters seen in fibro-myomata of the uterus. In many cases it is difficult to decide between a leio-myoma and a fibroma.

Epulis.—Among fibrous neoplasms must be classed the commonest form of growths which are found in the mouth, viz., fibrous epulides. These are usually connected with defective teeth, and always spring from the alveolar dental periosteum.

A typical example is represented in Fig. 93. It grew in the mouth of a tiger which had lived in this country for six years. Care must be taken not to confound simple overgrowths of the buccal mucous membrane with epulides.

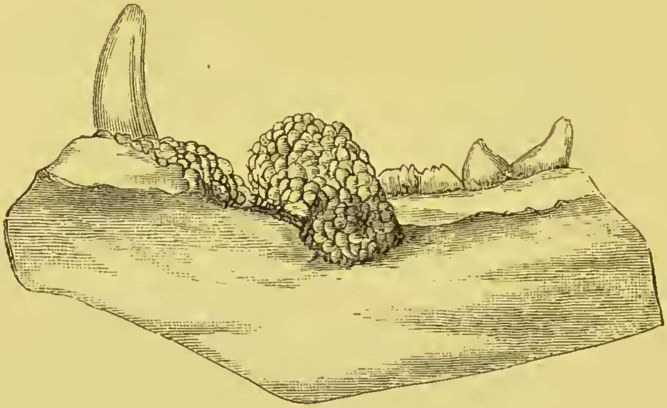

FIG. 93.—A FIBROUS EPULIS GROWING FROM THE ALVEOLAR DENTAL PERIOSTEUM OF AN ILL-DEVELOPED TOOTH IN A TIGER.

Epulides also occur in the mouths of horses and cattle, and an excellent example, growing from a carious tooth in the upper jaw of a wolf, fell into my hands. As yet all the specimens from animals I have had opportunities of examining were of the fibrous variety.

Melanotic Fibromata.—Cornil and Trasbot* describe, under this name, a very rare form of neoplasm which occurs in horses. They have observed three examples of it. The growths are black or of a sepia colour, and seem to arise from hyperplasia of the connective tissue, accompanied with a deposit of pigment in the meshes.

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* "De la Mélanose," 1868.

They are always single, generally of small volume, spheroidal or hemispherical in shape, and there is never more than one on the same animal. In two of the patients the growths were at the base of the tail or around the anus, and equal in size to a man's fist. One case, however, occurred in the flank; in all the animals the fibromata arose in the subcutaneous connective tissue. Histologically, the neoplasms presented the characters of fibrous tissue infiltrated with pigment-granules; in no part of the growth was it possible to detect sarcomatous elements. The melanotic fibromata grow slowly, and if removed do not recur. The third case, an old mare set aside on account of age, was allowed to live some time after the tumour was discovered. Eventually she was dissected in every part, but no secondary deposits could be detected.

M. Cadéac has recently described an example of this rare growth in a cow aged seven years. It was situated in the middle of the buttock, superficially, and was of small size. He makes reference to two other cases, also in cows.

Myxomata.—Up to the present time I have been unable to find any recorded case of a myxoma occurring in animals other than man.

The only example known to me is one in the possession of Mr. Shave, of the Royal Veterinary College, London, who afforded me an opportunity of examining some of the sections prepared for the microscope. It grew from the sides of the bladder of a horse, was of large size, and weighed eleven pounds. Microscopically, it presented all the characters of myxomatous tissue, being very translucent, and the cells having a ramified or stellate form. The tumour was intersected in many places by dense bands of fibrous tissue.

Lipomata.—Fatty tumours occur occasionally in domesticated, but are excessively rare in wild animals; even those born in captivity form no exception to the rule.

As in man, they usually arise from normal adipose tissue;

the occurrence of fatty tumours in the connective tissues of certain regions of the body, where fat is normally absent, is not unknown. Histologically such growths conform to the structure of adipose tissue; if the tumour be large it is usually made up of fatty lobules bound together by fibrous septa.

These growths are rarely the seat of secondary changes; the most important, perhaps, is the deposit of earthy matter (calcification).

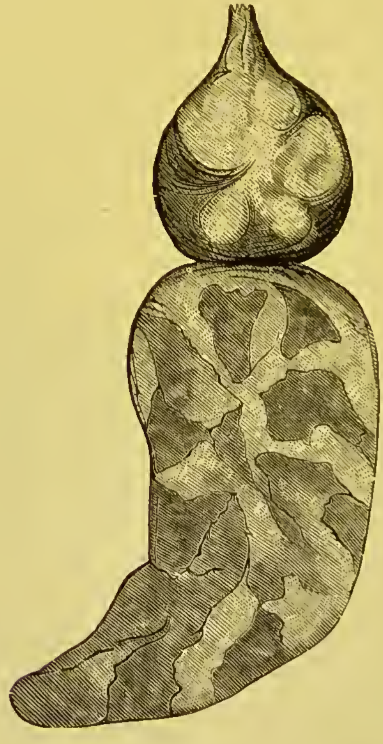

FIG. 94.—A LIPOMA HANGING PENDULOUS FROM THE INTESTINE OF AN OX (half the natural size).

It is not uncommon in oxen and horses to find fatty tumours, sometimes of considerable size, hanging pendulous from the intestines. There is every reason to regard them as overgrown appendices epiploicæ. A typical specimen is represented in Fig. 94, taken from the museum of the Royal College of Surgeons, London.

It was attached by a long narrow pedicle to the exterior of the intestine of an ox. It is composed of two chief parts united by a narrow isthmus, and each is of an elongated oval form. It is about six inches in length and two inches in diameter. The fat of which it is composed is firm, like beef-suet, and lobulated.

It is worthy of note that in most of these specimens the pedicle is narrow, this being probably produced by the constant swinging of the tumour from the bowel. In some cases the stalk becomes so thin that the lipoma breaks loose and falls into the peritoneal cavity.

On one occasion two fatty tumours, which had become detached in this way, were found in the peritoneal cavity of a mare. The larger one measured four inches by three, the lesser three inches by two and a half. They were completely invested by serous membrane, and on section presented the granular appearance characteristic of omental fat. The point of attachment of the pedicle could not be accurately determined. These specimens are now in the museum of the Middlesex Hospital. Pedunculated tumours of this kind are often a source of danger to the animal, as they are apt to lead to strangulation of the bowel. The "Veterinarian" (vol. viii., 1862) contains numerous cases illustrating this fact. The following instances will serve as examples:—

A horse, thirty-three years of age, was attacked with violent spasmodic colic, which ended fatally. The strangulation was found to be caused by a pedunculated lipoma, the size of a cricket ball, attached to the small intestines. The pedicle had encircled the gut, and strangulated it.

In the second case a horse died with all the symptoms of strangulation of the bowel. At the post-mortem examination two pedunculated lipomata were found swinging from the mesentery near to the attached border of the bowel, directly opposite each other. One of the tumours had by its weight torn through the mesentery and encircled the small intestine, leading to fatal strangulation.

A lipoma, weighing two pounds, has been found attached to the duodenum of a horse, in whom it was the cause of invagination of the bowel.

Lipomata attached to the bowel are not unknown in man. Virchow, in his great work on tumours, figures an undoubted example of pendulent fatty tumours hanging from the colon in a man, and draws attention to the fact that the narrow pedicle of such tumours easily undergoes torsion, leading to defective nutrition of the mass, and secondary changes, such as cretification Later, these masses, large or small, may become detached, and then, as loose bodies, occupy the peritoneal cavity, often giving rise to curiosity at the autopsy as to their probable origin, as well as on account of the hardness and singular shapes some of them assume.

All loose bodies in the peritoneum do not arise in this manner; some are calcified subserous uterine fibro-myomata which have broken their pedicles.

Lipomata occurring in such situations as those last described are easily explained; but a fatty tumour in the substance of the heart is not so comprehensible. A remarkable case of this kind may be found in the museum of the Royal College of Surgeons; it is thus described in the catalogue:—

The heart of a sheep greatly enlarged by the growth of fat on its exterior and in its cavity. The muscular walls of the auricles and ventricles are very thin. The cavity of the right ventricle is nearly filled by a lobulated mass of suet-like fat, which has distended the walls and pressed back the tricuspid valve so as nearly to close the orifice into the auricle. The lining membrane of the ventricle and the pulmonary artery is healthy. The cavity of the left auricle is encroached upon by a large mass of fat projecting into its interior, and the lower half of the left ventricle is occupied by a tumour of the same kind as that in the right ventricle. The valves and the aorta are healthy. The heart weighed two pounds three ounces; the weight of the fat added to it is therefore about twenty-five ounces. The sheep from which it was taken was very inactive, and had dyspnœa on exertion. There was a great accumulation of fat around the kidneys.

The mass of fat lying anterior to the testes or ovaries in male and female frogs and toads respectively, known to anatomists as the "corpus adiposum," is an interesting structure. The researches of embryologists prove most conclusively that the fat-body is really the degenerated remains of the anterior portion of the genital ridge of the embryo, the mass of cells from the posterior part of which the ovary or testis is developed. Thus every frog born into this world normally inherits a "lipoma" in connection with its reproductive gland. Occasionally it happens that this fatty degeneration does not limit itself to the anterior portion of the genital ridge, but may involve the testicles also.

The accompanying figures (Fig. 95) represent the corpus adiposum of a frog (A), of a toad (B), and an abnormal one (C), involving the testis.

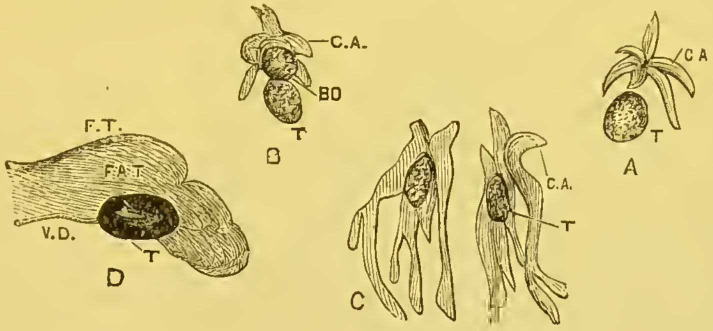

FIG. 95.

(A) The testis, T, and corpus adiposum, C.A., of a Frog (*Rana temporaria*). (B) The testis, T, corpus adiposum, C.A., and Bidder's organ (remnant of ovary) of a Toad (*Bufo vulgaris*). (C) Abnormal corpus adiposum, involving testis, of a young Frog (*Rana temporaria*). (D) Malformation of reproductive organs of a Monkey. T, testis; V.D., vas deferens; F.T., Fallopian tube. Fat replacing the ovary. The uterus was of the usual shape, but the vagina small, with a narrow orifice.

In an example of malformation of the reproductive organs which occurred in a monkey (*Cercopithecus lalandii*), in which case there was a uterus and vagina, associated with testes, a large mass of fat, exactly recalling a corpus adiposum of the frog, lay above each testis. It may be argued that, strictly speaking, these should rather be considered as degenerations; but as they increase in size, and are foreign to the matrix in which they are situated, strictly they fall in the ranks of neoplasms.

Those masses of fat, usually called fatty tumours, which occur in the subcutaneous tissue, are clinically tumours, have no claim to be designated as neoplasms, but ought to be regarded rather as examples of local hyperplasia. The term lipomata should be reserved for those tumours, composed of fat, which grow in such situations as the palm of the hand, in the substance of the tongue, or in relation with striped muscle. It is only in such situations as these that we can truly say that the lipoma presents *histological diversity* from the matrix in which it is situated.

This group shows how important it is to distinguish between a tumour from a clinical point of view, and a neoplasm from the pathologist's standpoint. A fatty tumour in the subcutaneous tissue of the body, and one growing in the substance of the tongue, are to the surgeon identical, but their genesis is totally different.

Enchondromata.—This term is applied to tumours which consist essentially of cartilage. The fact that these growths may be pervaded by tracts of fibrous tissue for the conveyance of blood-vessels to nourish the abnormal mass, does not at all affect the definition. Some pathologists propose to call those growths which arise as a local overgrowth of cartilage—ecchondroses. This limitation of the term will not hold good, for there is abundant evidence to support Virchow's view regarding the probability that many osseous enchondromata originate in remnants of cartilage which have abnormally remained unossified.

In his work on tumours,* he mentions the occurrence of cartilaginous tumours in patients who had shown evidence of rickets in early life, or who bore traces of it in after life. Virchow further points out that these tumours occur with *extraordinary frequency in the first* years of life.

In one case a tumour appeared on the little finger soon after rickets had manifested itself. The tumour, which was removed twenty-seven years later, was found to be an enchondroma (Joh. Müller).

In another patient, aged twenty-six, there were multiple enchondromata on the metacarpals and phalanges of the hand, on the metatarsal bones of one foot, and on the corresponding tibia. There was evidence of rickets; the tumours appeared at the age of three years (Lennoir, case quoted and figured by Lebert). Virchow also gives references to similar cases. It is a curious circumstance that the cartilage found in these tumours bears a very striking resemblance, under the microscope, to the tissue so characteristic of the blue line of rickets. Remnants of untransformed cartilage in the neighbourhood of, but detached from the epiphysial line are to be found in rickety bones, and an example is represented in Fig. 96.

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* French translation, vol. i., p. 477.

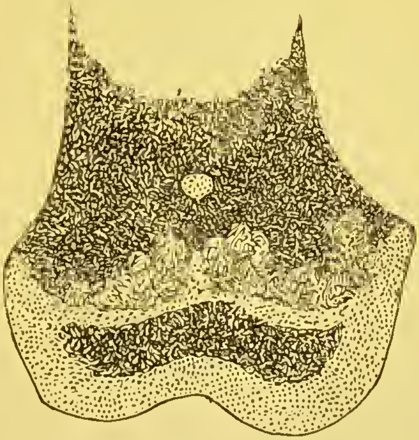

FIG. 96.—RICKETY EPIPHYSIS OF FEMUR WITH A CARTILAGE ISLAND.

In the "Path. Soc. Trans.," vol. xxxiv., p. 312, I gave an account of rickets in animals, and adduced facts to show that the irregular mode of ossification of the epiphysis in this disease occurring in monkeys, often left "islets" of cartilage untransformed as shown in Fig. 96. At that time I was unaware of the observations of Virchow. In the same year I communicated to the Pathological Society the following examples of cartilage-tumours which occurred in a rickety lizard, and a rhea similarly affected :—

A lizard (an Indian monitor), which was extensively affected with rickets, presented numerous enchondromata in various parts of its body. The two largest were found at the fifth and seventh cervical vertebræ, and considerably expanded their centra. A large mass surrounded the glenoid cavity of each scapula. The right humerus presented two large growths immediately above the condyles (Fig. 98). The

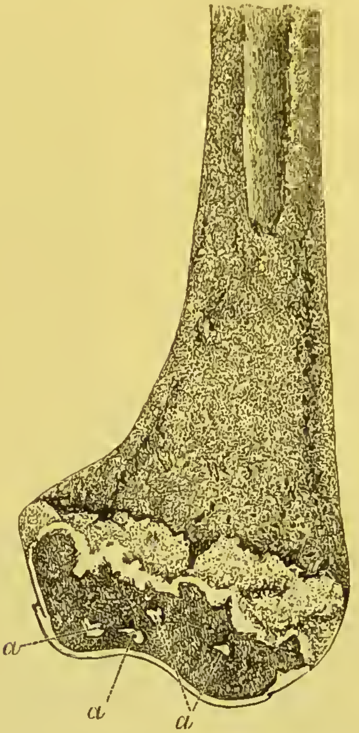

FIG. 97.—LOWER EXTREMITY OF THE FEMUR OF A BABOON. Showing a rickety epiphysis and cartilage "islets," *a*, *a*, *a*.

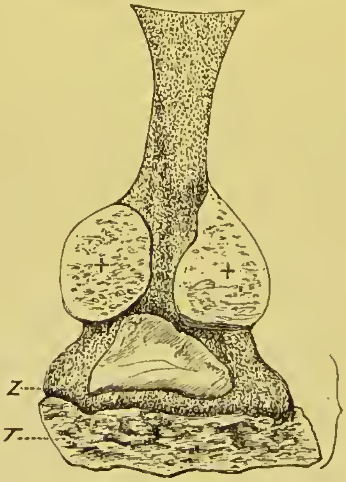

FIG. 98.—HUMERUS OF A MONITOR LIZARD WITH ENCHONDROMATA. *Z*, the growing zone. *T*, terminal cartilage.

left humerus presented one, the metacarpal bones possessed two, near their distal extremities, and four were found growing on the cornua of the hyoid bone; they were composed of hyaline cartilage.

A bird (a young rhea) died in consequence of a fractured leg. Its skeleton was affected throughout with rickets, but on each metatarsal bone an enchondroma, the size of a walnut, existed. The metatarsus of birds is confluent; that is to say, the three bones forming that segment of the pes are fused so as to form a single bone. At the proximal end, in young birds, an epiphysis may be detected. This epiphysis really represents the distal row of tarsal bones seen in mammals, but in birds it fuses with the metatarsus. A line of cartilage exists between the two parts in all young birds. In the case under consideration, the tumour clearly originated as an

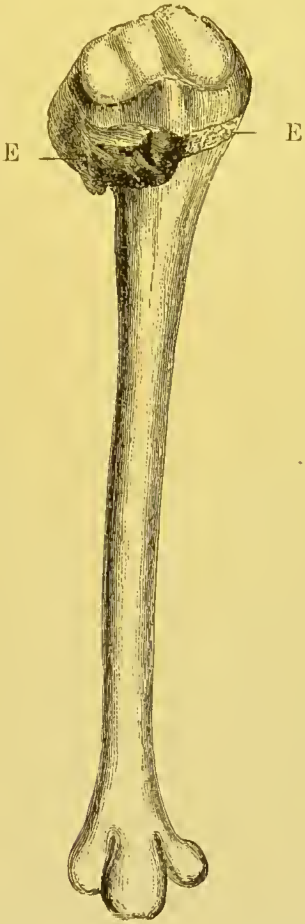

FIG. 99.—METATARSAL OF A BIRD (*RHEA AMERICANA*) WITH AN ECCHONDROSIS IN CONNECTION WITH ITS EPIPHYSIS, E.

overgrowth of this epiphysial cartilage, and agreed with it in structural details (Fig. 99). This would be a typical example of an ecchondrosis.

Among curious situations for enchondromatous tumours to occur must be mentioned the lungs, mammary gland, and the testicle.

The growth in one well-reported case* was found in the lung of an ass. It occupied the dorsal surface of the left lung posterior to the root. The tumour weighed eighty-four drachms, and measured seven inches in length, eight inches in width, and three inches in thickness. It was microscopically examined by Barlow, the well-known veterinary teacher of Edinburgh. It was composed of a large quantity of fibrous tissue, which formed a dense interlacement throughout the tumour. Cells, resembling cartilage-cells, were found with an amorphous intercellular material. In the softer portions of the mass the cells were fewer in number, and the intercellular material contained numerous molecules and granules. In these parts the consistence of the tumour was softer than any variety of cartilage. Calcareous particles were diffused throughout the growth.

A neoplasm of like character has been described,† growing in the mammary gland of a bitch. Similar tumours have been found in connection with the testicles of colts.‡ In one instance a cartilaginous tumour, removed from this situation, was found to contain a calcareous mass as large as a hen's egg. Since Mr. Butlin § has investigated the question of the very frequent occurrence of masses of cartilages in spindle-celled sarcomata in man, it seems exceedingly probable that the above instances are to be regarded as sarcomata undergoing chondrification. This subject will be more fully dealt with in the chapter devoted to sarcomata.

The further consideration of enchondromata occurring in various situations, will be deferred until we come to deal with the etiology of the mesoblastic neoplasms, where evidence will be adduced to further support the view of their origin in what may be conveniently termed "cartilage-islands."

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* "Veterinarian," 1851.

† "Veterinarian," 4th series, vol. xvii.

‡ *Ibid.*, 4th series, vol. xxviii.

§ "Sarcoma and Carcinoma," London, 1882.

Osteomata.—The osteomata are neoplasms composed of osseous tissue; they may occur in any part of the body, but their usual seat is in connection with the bones. It is customary to include all kinds of osseous formations under this term, irrespective of their origin. In some of the best museums in London, specimens are often described as exostoses, which are palpably of inflammatory origin. In this section the diffuse bony overgrowths known as hyperostoses, those of less extent known as osteophytes, and the heteroplastic deposits which may arise in tumours, in brain membranes, diaphragm, muscles, and in the choroid tunic of the eye, will be excluded.

Bony tumours, strictly speaking, are those circumscribed growths of non-inflammatory origin generally recognized under the term *Exostoses*, and similar masses occurring in the interior of bones, known as *Enostoses*.

An osteoma may be regarded as a variety of enchondroma; indeed, there is every reason to believe that they originate in cartilage-rudiments, and that the ossification is a later change.

Growing osteomata are provided with a definite layer of cartilage, they are most frequent in situations where hyaline cartilage abounds. Like enchondromata, they are widely diffused throughout the whole sub-kingdom Vertebrata. Some examples will now be considered.

Paul Gervais* has recorded some admirable examples met with in fish. In Fig. 100 the anterior vertebræ and corresponding dorsal rays of a scabbard fish (Lepidopus) are represented of the natural size. Four of the dorsal rays bear an exostosis on their under surface.

In another fish (*Pagrus unicolor*), obtained from Australia, a large exostosis was found on the occipital crest. It is represented, two-thirds its natural size, in Fig. 101. A similar, but much smaller, growth lay posterior to it.

A transverse section of a portion of the large osteoma showed that the growth was composed of successive layers of tissue resembling dentine, traversed by nutrient canals, each layer of this vaso-dentine being separated by a tract of more compact osseous tissue, as shown in Fig. 101.

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* "Journal de Zoologie," vol. iv., 1875.

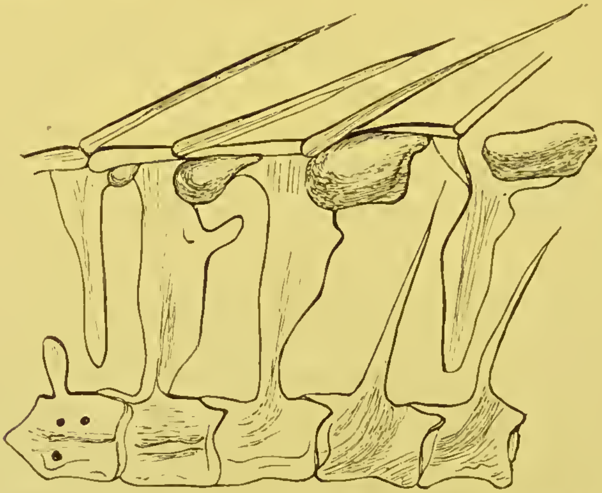

Fig. 100.—Five Vertebræ of a Fish (Lepidopus) with Exostoses. (After Gervais.)

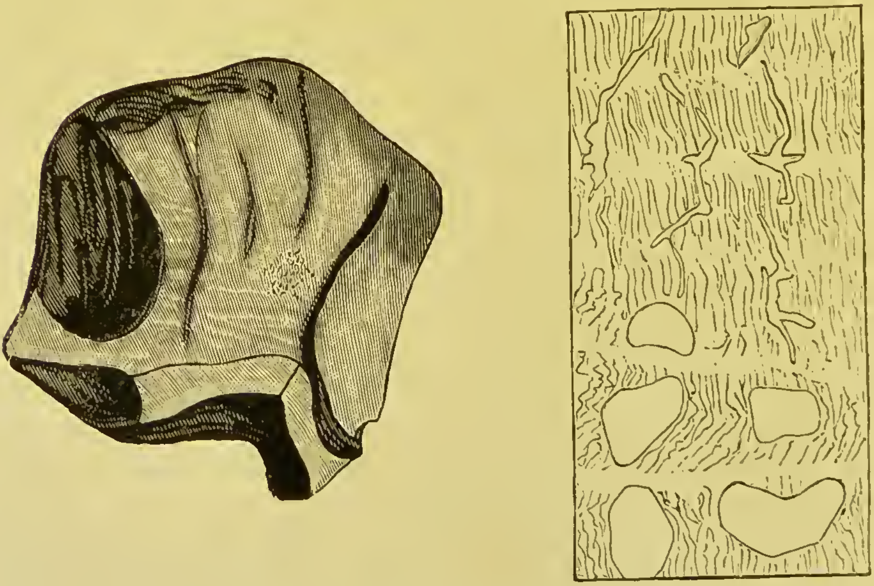

Fig. 101.—Exostosis of a Fish (*Pagrus unicolor*) growing from the Occipital Crest (one-third its natural size).

The accompanying figure shows its resemblance histologically to vaso-dentine.

Tissue of this character enters largely into the formation of the hard parts of the skeleton of the majority of fish, more especially in connection with the teeth, so that its occurrence in exostoses of fish is not more remarkable than osseous tissue in the morbid growths of mammals. It is somewhat singular that the only traces of this piscine tissue in animals other than fish are confined to the teeth of very few mammals, the extinct megatherium particularly, and in the teeth of man it only occurs as a rare pathological production in the form of vascular dentine.

The museum of the Royal College of Surgeons contains the following examples of exostoses in fish :—

The first one is an example of an exostosis, half an inch in diameter, growing from the vertebræ of a cod-fish (*Gadus morrhuæ*). An important feature in this growth, which is made up of hard, compact bone, is that it springs from the meeting-place of two vertebræ at a spot corresponding to the intervertebral substance in a mammal. The second example is that of an exostosis on the dentary bone of a pike; it is finely spiculated, and springs from the alveolar border of the bone. It has displaced two of the teeth inwards.

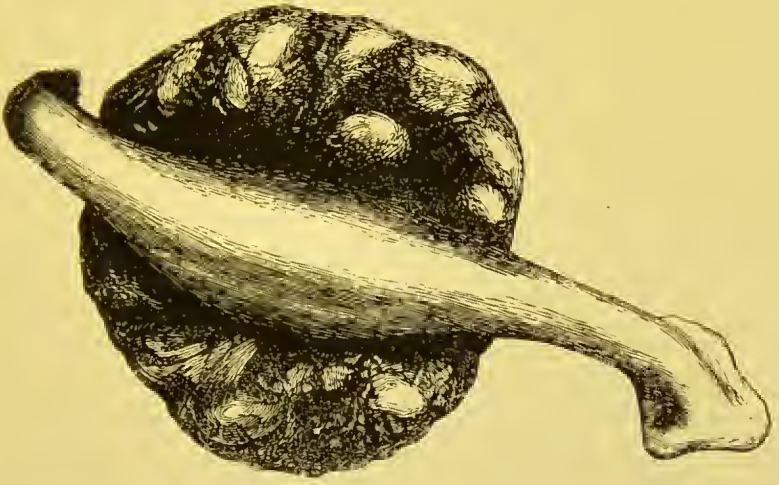

FIG. 102.—EXOSTOSIS ON THE SUPERIOR MAXILLA OF A COD-FISH.

The third case is that of a heavy disc-shaped osseous tumour, about two inches in diameter, and half an inch in thickness, growing from the superior maxilla of a cod-fish (Fig. 102). In its external appearance and internal structure it resembles the tumour on the vertebræ of the cod-fish before quoted.

The museum possesses a portion of a large ivory-like tumour, which grew from the forehead of an ox, and appeared to have had its origin in the frontal sinuses. It is spheroidal in shape, weighs upwards of sixteen pounds, and measures eight and a half inches in its greatest diameter. Its surface is tuberous, but hard and smooth like an elephant's tusk. The whole of the tumour has the microscopic structure of bone. There is also exhibited the ulna of a fowl, which is embedded, except at its articular surfaces, in a very compact bony tumour, which both fills its cavity and grows nearly an inch beyond the normal compact wall.

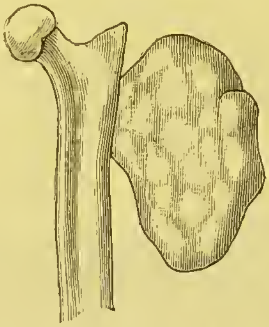

FIG. 103.—AN EXOSTOSIS GROWING FROM THE FEMUR OF A CAT. (Guy's Hospital Museum.) Natural size.

Osteomata have been found connected with the nasal septum in the horse.

In one recorded case* the mass was distinctly pedunculated, measured eleven and a half inches in circumference, and weighed twenty-one ounces. It had made its way into the antrum, causing absorption of the outer wall of the nasal fossa.

In another instance an osseous tumour was safely removed from the palatal surface of the premaxillary bone of a three-year-old colt. The tumour had displaced the incisor teeth. It measured four inches in length, nearly two and a half inches in width, and one and a half inch in thickness. It weighed five ounces. In microscopical characters this and the preceding growth conformed to the structure of true bone.

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* "Veterinarian," vol. xxviii., p. 84.

In the human subject, exostoses have been known to break from their attachment and lie loose in the cellular tissue. The following cases appear to be of this nature:—

(1) An exostosis, which was removed from a horse, weighed twenty-seven ounces: it was loosely connected by cellular tissue to the bones of the stifle-joint (knee), and had been observed to increase in size from a hazel-nut to ten inches in diameter. It was surrounded by cartilage.

(2) An osteoma, loosely attached to the inner and front part of a horse's hock. The bony mass was of the size of an orange ("Veterinarian").

The museum of the Royal Veterinary College, London, contains some specimens of exostoses removed from the skulls of horses. Three of them, formed of very hard dense bone, exactly resembling that which composes the "ivory exostoses" of human pathology, were removed from the neighbourhood of the petrous and mastoid portion of the temporal bone—a region of the human skull where osseous growths occur with extreme frequency. The largest of these tumours measures eight inches in length, five inches in width, and three inches in thickness. Among them is one which grew on the inner aspect of the cranium. It is of less density than the others, and resembles pumice-stone in appearance. There is no variety of new formation so widely diffused as the bony tumour or exostosis. Its presence has been recorded in fish, recent and extinct, in amphibians, in birds, and in many varieties of mammals. The universal occurrence of osteomata is to be explained by the existence in all vertebrates, of that peculiar substance which forms so large a part of the skeleton of lower animals, and, for a brief period, that of the highest types—hyaline cartilage.

Odontomata.—An odontome is a neoplasm composed of dental tissues, arising in connection with teeth or germs of teeth. Up to the present time, the only classification of odontomes in use is the very unsatisfactory one introduced by Broca in his "Traité des Tumeurs," vol. ii., 1869, where he endeavours to arrange odontomes in classes according to

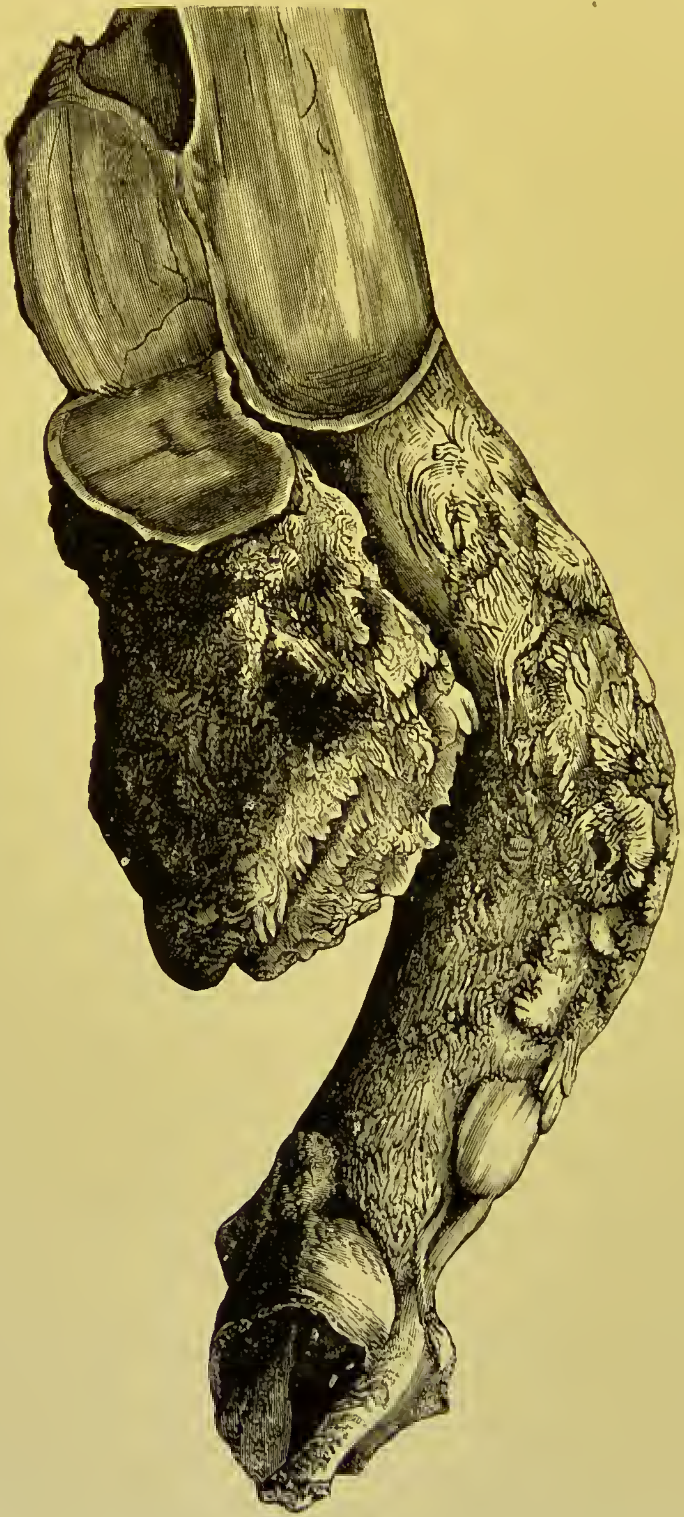

FIG. 104.—ODONTOME ON THE TUSK OF A YOUNG WHITE ELEPHANT OF SIAM. One-third the size of nature. (After Magitot.)

the stage of development of the tooth at which the tumours probably arise. Almost every writer on dental neoplasms since Broca wrote his well-known work, has found occasion to complain of the eminently unsatisfactory character of the classification adopted by him; but no one has attempted to improve matters by suggesting a better one. In this instance the plan followed with regard to other tumours will be adopted, viz., to arrange them according to their histological structure.

The teeth of most mammals consist of three distinct structures—(1) enamel, which is of epiblastic origin; (2) dentine; and (3) cementum. The two last arise from mesoblastic tissues. To these must be added the modification of dentine, known as osteo-dentine.

I am unaware of enamel ever entering in any considerable quantity into the formation of an odontome, hence it is not necessary to make provision for it; this is very convenient, for, if such were the case, an odontome composed of enamel would have to be classed among the epithelial tumours, whereas now all the odontomes I am acquainted with consist of the other elements of the teeth, and strictly come among mesoblastic tissues.

Classification of the Odontomata.

1. Cementomata.
2. Dentomata.
3. Osteo-dentomata.
4. Mixed Odontomata.

1. *Cementomata.*—In this variety the bulk of the tumour is made up of cementum, often arranged in layers if the tumour is a large one. It is a tissue like true bone, slightly modified in structure, containing lacunæ and canaliculi. When the mass is very thick it contains Haversian canals. Seeing that the teeth of ruminants contain a large proportion of cementum, it need not surprise us to find cementomata especially frequent among them, and that they attain considerable dimensions.

Broca* has described and figured some excellent examples of this variety in the horse; the abnormal masses were attached to the molar teeth, and composed almost entirely of cementum; some of the specimens mentioned by this observer are deposited in the museum at Alfort. It is curious to note that in some of these instances the tumours are worn on one surface, having been used in mastication. Mr. Charles Tomes[*] described an example of this variety of odontome connected with the molar of a horse. The mass was five or six times as large as the tooth, and weighed ten ounces. On the upper surface it was in one place deeply worn and grooved by the opposite teeth in mastication. The great bulk of the tumour was in front of the molar to which it was attached. Examined microscopically, it was found to be composed entirely of cementum. The outside consisted of numerous parallel laminæ of this tissue, not differing in any marked character from that which naturally covers the tooth-fang in ungulata. Inside this laminated covering there is a substance quite devoid of anything like lamination, in which numerous bone-corpuscles are found, and an abundance of those globular forms which are seen in secondary dentine, or in dentine of imperfect formation.

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* "Traité des Tumeurs."

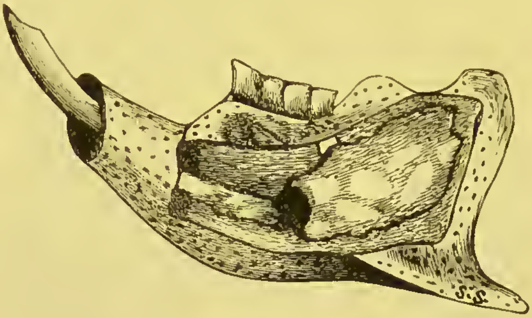

Fig. 105.—An Odontome connected with the Incisor of an Agouti. It is composed of cementum.

Other observers, as E. M. Rosseaux, Goubaux, and Magitot, have recorded instances of odontomata occurring in connection with the teeth of horses. Many cases reported by Magitot, however, were taken from the museum of the Veterinary School at Alfort, and have been already alluded to.

Tumours composed almost entirely of cementum are not confined to ungulate animals. In Fig. 105 is represented the left lower jaw of an agouti (*Dasyprocta agouti*); attached to the root of the lower incisor is an odontome of fair proportions considering the size of the animal. On splitting the tooth and the tumour longitudinally, the new growth was seen to surround the root of the tooth on all sides.

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[*] "Trans. Odonto. Soc.," 1871-72.

Sections of this hard substance show that the tumour is composed chiefly of cementum; small patches of dentine can be detected here and there throughout the mass, and dark areas resembling interglobular spaces; but more than three-fourths consist of cementum.

2. *Dentomata.*—These growths are made up chiefly of dentine, but usually of the variety known as osteo- or secondary dentine.

This substance occurs largely in the teeth of the walrus and cetacea (Odontocetes). It is very frequently developed in the tusks of elephants consequent on irritation, and in the pulp of human teeth when attacked by caries.

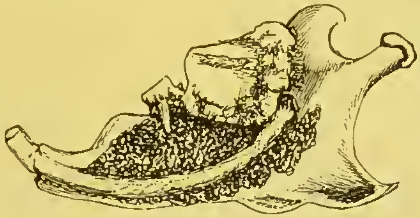

FIG. 106.—LOWER JAW OF A YOUNG MARMOT, WITH A LARGE ODONTOME CONNECTED WITH THE ROOT OF THE LOWER INCISOR TOOTH.

Several examples of dentomata have come under my notice. In one remarkable case I found no less than four of these growths in the mouth of a prairie marmot (*Cynomys Ludovicianus*), each one in connection with the root of an incisor tooth. Those in the lower jaw were much larger than the growths in the upper one. The arrangement of the lower incisor of the left side is represented in Fig. 106, where the outer plate of the maxillary bone has been cut away in order to expose the odontome *in situ.*

The tooth projects very little above the alveolar margin, and has a thin cap of enamel; passing backwards, it lies below the inferior dental canal until its extremity reaches the coronoid process, at this spot it is lost in a mass of hard tissue. The portion of the tooth which lies hidden in the bone presents a rugged surface, probably the result of inflammation. The odontome mounts upwards as high as the summit of the coronoid process, which has become hollowed out and thinned to contain it, the pressure of the growth having caused considerable atrophy of the bone; in some places the maxilla was so thinned as to yield to the pressure of the nail.

The tumour has a slightly lobulated appearance, as if made of spherules; the surface in places presents irregular markings. It measures in length three-fourths of an inch, in width one-third of an inch, and is half an inch in depth. Remembering that the lower jaw is only three inches long by one inch in the widest part, this tumour is of very considerable size relative to the bulk of the animal. The truncated hollow, normal in these teeth, is completely filled with secondary dentine, except in a few irregular spaces here and there. The main mass of the growth is dentine, some parts of it displaying interglobular spaces; patches of enamel may be seen, and a small quantity of cementum surrounds the tumour, and in places runs into the interior.

Fig. 107 shows a section of the tumour magnified about ten times. At the base is seen the small pedicle by which the tooth and odontome were attached.

As far as I can learn, odontomata, made up entirely, or in chief part, of dentine, such as is ordinarily seen in the teeth, are very rare in man.

An instance of this, however, is afforded by a case recorded by Dr. Forget,[*] which occurred in a man aged twenty. The tumour was of the size of an egg, and its surface was covered with minute tubercles, which were invested by a layer of enamel. The tumour was composed of dentine, but a small amount of enamel and cementum were present.

3. *Osteo-dentomata.*—Structurally these are formed of hard tissue, traversed by canals which contain blood-vessels. The dentinal matter may be deposited in a globular form; from the vascular canals, tubules, resembling in their size and mode of ramification those of dentine, pass off and lose themselves indefinitely in the surrounding hard structure.

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[*] "Dental Anomalies."

Tumours composed of osteo-dentine are occasionally found connected with the tusks of elephants. The museum of the Royal College of Surgeons possesses some very good examples. The museum of the Odontological Society of Great Britain has an excellent specimen also in connection with the tusk of an elephant. This has been examined microscopically by Mr. C. Tomes, and found to be composed of this variety of dentine.

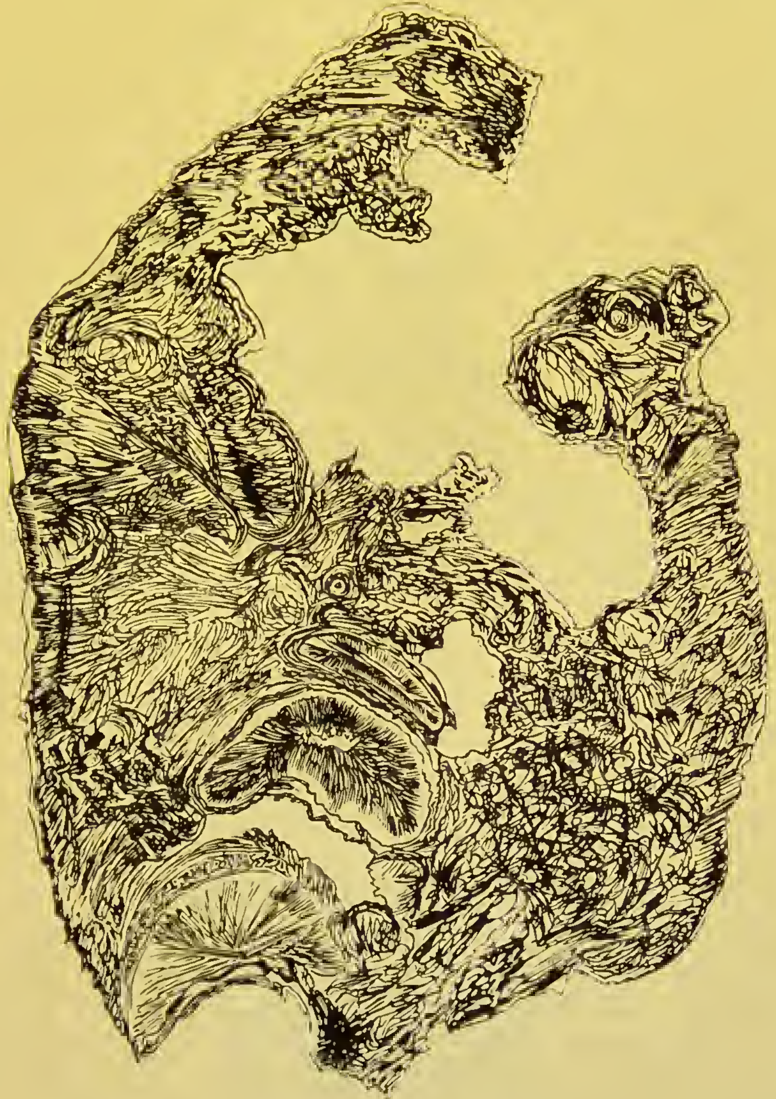

FIG. 107.—SECTION OF AN ODONTOME FROM A MARMOT.
(Magnified about ten times.)

4. *Mixed Odontomata.*—Under this division will be included all those tumours where the three dental tissues—enamel, dentine, and cementum—are so intimately mixed that there is not sufficient preponderance of any one tissue to separate the tumour, and place it under any of the previous headings.

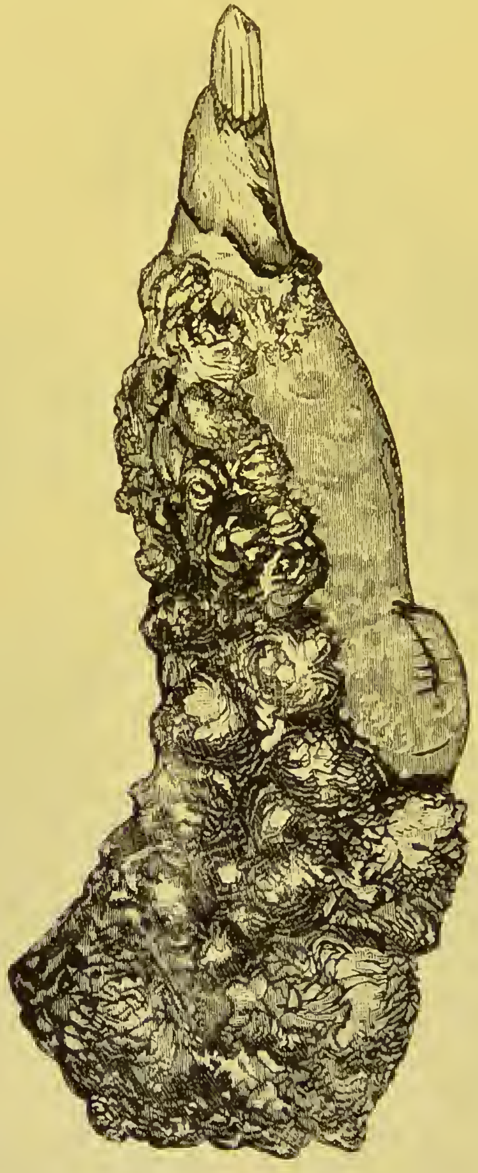

FIG. 108.—ODONTOME IN CONNECTION WITH AN ELEPHANT'S TUSK.

To this class most odontomata occurring in the human subject must be referred. I have gone very carefully over the recorded cases, and find the majority composed of cementum and dentine in varying proportions; some of them possessed a variable quantity of enamel.

The remaining cases will be described in relation with their bearing on the origin of these growths.

Virchow quotes Leisering concerning a very curious tumour found in the region of the last molar tooth in the inferior maxilla of a calf. It distended the alveolus, and had acquired a polypoid form, measuring three inches by seven and a half inches. The surface was tuberculated, each little papilla being formed of dentine covered with an enamel cap. The tumour itself was composed of connective tissue, vessels, and dentine. Robin * found, in the inferior maxilla of a child two years and a half old, a tumour, fibrous in appearance, with papillæ, presenting distinctly dentine and enamel. It seems to me exceedingly probable that in these two cases we have to deal with odontomata in an early stage. The following example is of a similar nature :—

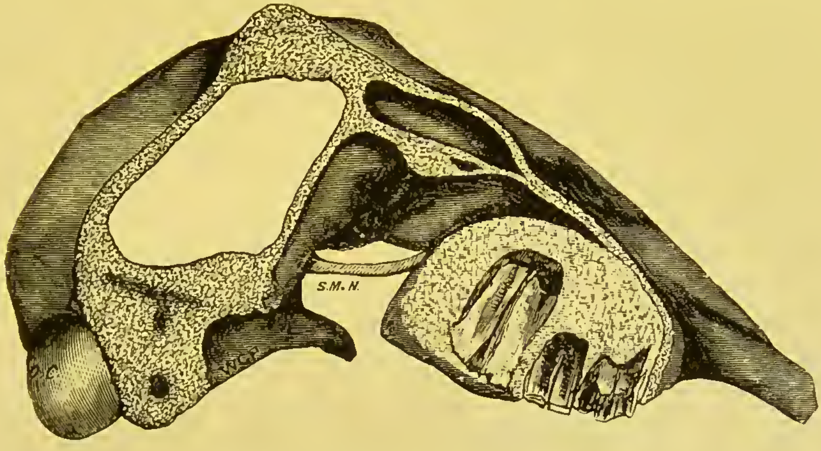

FIG. 109.—SECTION THROUGH THE SKULL OF A GOAT.
An odontome in the course of formation. S.M.N., the sup. maxillary nerve.

A hybrid goat (a cross between a Nubian and the common goat), when three months old, was found to exhibit marked enlargements on each side of the face, in the neighbour-

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* "Mém. de la Soc. de Biologie," 1863, ser. iii., t. iv., p. 301.

hood of the antra and the angles of the lower jaws. About one month later the animal died.

On making a section through the skull, each antrum was found occupied by a very thick-walled cyst, in the interior of which was a molar tooth (probably the first permanent); the cyst-walls were an inch in thickness. Its general appearance on section is shown in Fig. 109. There can be little doubt that the parietes of the cyst are really the walls of the tooth-follicle enormously thickened; on making sections of the part it is found to be made of layers of connective tissue undergoing ossification, agreeing in structural details with the tooth-sac of a healthy goat compared with it.

The growths in the lower jaw were situated near the angles, and agreed in structure with those of the upper jaw, but did not contain teeth. Altogether there were four of the curious cysts in this goat; the surrounding bony tissue was so soft that it could easily be cut with a knife, yet the other parts of the skeleton were firm and hard.

Soon after finding this case, I had an opportunity of inspecting a similar specimen at the Royal Veterinary College. London, also in a goat; but the abnormal masses were confined to the lower jaw, and were thought to be sarcomata. Virchow has recorded a specimen of this nature under the name of a soft osteoma in the jaw of a goat. These are the only three examples I am acquainted with; probably they will be found not infrequent if carefully looked for. They possess a considerable amount of interest, for they shed some light on the etiology of odontomes. A tooth is built up of three structures of totally different origin—enamel from the enamel organ, dentine from the papilla, and cementum from the alveolar dental periosteum and tooth-follicle. Cementomata, or odontomes composed almost entirely of cementum, are most common in ungulates; they are generally attached to, or surround, the molar teeth, and often present a laminated arrangement (see especially Mr. Tomes' case referred to on p. 264). I am strongly of opinion that in the growths in the jaws of these goats we have to deal with cementomata in the the course of development, and that had these animals lived the overgrown follicles would probably have become hard tumours. Overgrowth of the dentine papillæ in the same way gives rise to dentomata. Abnormalities of the enamel-germ are considered in chapter xix.

For an account of the chief examples of odontomata occurring in the human subject, Heath's work "On the Injuries and Diseases of the Jaws" should be consulted.

ANGIOMATA.

Simple Angiomata.—In this class the neoplasm is composed of new vessels resembling normal arteries, veins, or capillaries, in a dilated and tortuous condition, bound together by connective tissue. Some of the vessels are of new formation, but many of them must be considered as dilatations or enlargements of pre-existing vessels.

Angiomata are rare in animals. Röll insisted on this in 1856, and showed that the most frequent seats of their manifestations are the lips, eyelids, mammary glands, and prepuce.

Cavernous Angiomata.—It is usual to include under this heading venous vascular tumours and aneurism by anastomosis. They consist of an erectile cavernous tissue, such as exists normally in the corpus spongiosum, the comb of the cock, and the knob on the beaks of certain water-fowl, notably the swan The structure of these appendages serves well as a physio-. logical type for vascular tumours. Virchow cites cases from Gurlt* of aneurism by anastomosis in the horse and dog. In the horse the upper lip was the part affected; the angioma was of the size of a five-franc piece. The part was easily injected from the veins, and the growth occupied the whole thickness of the skin.

Sims Woodhead † mentions that although angiomata are not very frequently met with in the liver of the human subject, yet in the liver of the domestic cat they are of common occurrence. They may be detected, as a rule, near the surface, and may be seen shining through the capsule as purple or dark claret-coloured patches. Not only in the cat, but in cat-like animals, the *Felidæ*, this condition may occasionally be seen; but the morbid patches are, as a rule, small, rarely exceeding a pea in size; unless especially looked for they are very liable to be missed. The most marked case of cavernous angioma that has yet come under my notice occurred in a dog fourteen years old. In this instance, six tumours, of the size of walnuts, occupied the liver-substance, and formed prominences on its exterior. They were of a dark purple colour, and, when cut into, were found to consist of cavernous spaces filled with blood. The morbid masses had given rise to no symptoms during life.

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* Gurlt: "Lehrb. der Path. Anat. der Haussäugethiere."
† "Practical Pathology."

Lymphangiomata are a variety of angiomata, but the morbid growth is composed of dilated lymph-vessels. They are of very rare occurrence.

Myomata.—Myomatous neoplasms consist essentially of new-formed muscular fibres. They are limited to certain regions of the body. Two varieties are recognized—*Rabdo-myomata*, or striated muscle-tumours, and *Leio-myomata*, or smooth muscle-tumours.

Rabdo-myomata, or tumours containing striped muscle-fibre, occur in curious situations. The most common places for them are the regions where teratomata occur most frequently, such as the sacral and sphenoidal regions, and in the ovary and testicle; indeed, muscle-fibre is usually a component element of these remarkable formations. Apart from these regions, tumours composed in part of striated muscular tissue are most common in the kidney. The majority of recorded cases in this organ have been found in young children and fœtuses, but always associated with sarcomatous elements. Cohnheim takes advantage of this circumstance, and uses it to support his view of the origin of tumours from germinal rudiments. His opinion is that these growths in the kidney arise from portions of the mesoblastic somites, so largely concerned in the development of the muscles of the back, which are accidentally associated with the kidney. The question will be more fully dealt with when we come to consider teratomata generally.

Gowers reported in "Path. Soc. Trans.," vol. xxvii., p. 19, a curious example consisting of a combination of a lipoma and rhabdo-myoma implicating the spinal cord. The neoplasm lay beneath the dura mater.

Leiomyomata are met with in the uterus, where they form rounded masses, at times of considerable size. In this situation the bulk of the tumour is made up of fibrous tissue, constituting a fibro-myoma. On transverse section, they offer a whorled arrangement, which is at once peculiar and characteristic.

Fibro-myomata are not unknown in animals. Instances have been recorded in cows. Virchow, in his great work on "Tumours," speaks of hard growths of all kinds, which have been found in connection with the ovaries, vagina, and uterus of animals. These have been habitually described as sarcomata or fibroids. He quotes cases from the works of Gurlt and Förster as evidence of the occurrence of fleshy tumours, developed in the walls of the uterus, especially between the muscular layer and the mucous membrane, in the mare, cow, and pig. Leisering found numerous fibroids in the submucous tissue of the vagina of a bitch, as well as fibroids in the uterus of a cow. Virchow concludes the chapter by stating that the details of the intimate structure of these tumours, occurring in animals, requires more precision, and it remains for further researches to establish their nature. Myomata are certainly not common in animals. One undoubted case has come under my notice in a baboon, where the histological details were perfectly characteristic of a leiomyoma. The body of the uterus seemed to form part of one general tumour, and was very much enlarged. The Fallopian tubes and ovaries of each side were involved, and in part incorporated in the walls of the uterus.

Undoubted cases have also occurred in the vagina of mares, cows, and bitches: this seems to be a frequent situation for such growths in the form of polypi.

It is exceedingly probable that many of the tumours described as fibrous were in the first instance leiomyomata, which have retrograded into fibrous tissue (see p. 244).

In the "Path. Soc. Trans.," vol. xxxiv., Dr. Finlay has recorded a case of uterine fibro-myoma of ten years' standing, which eventually underwent sarcomatous degeneration; secondary nodules made their appearance in the lung, heart, diaphragm, and kidney, and brought about the death of the woman. At the post-mortem the tumour, which measured six inches by four and a half inches, was softened, and in part consisted of an irregular cavity. The lower part of the tumour was firm, and had the appearance of a fibroid. The whole was of a whitish colour, and was surrounded by a distinct capsule. Microscopically, the tumour presents the characters of a leiomyoma intermixed with spindle-celled elements. Dr. Finlay gives references to a few other cases reported by Schrœder,* Hutchinson,† and by Callender.‡

An example of this rare form of degeneration came under my observation in a mare. A tumour of the size of a large orange was attached to the interior of the uterus by a pedicle composed entirely of mucous membrane, which membrane also formed a complete investment for the tumour. On section it was found to be soft and of a yellowish white colour; at places near the pedicle small calcareous particles were found.

Microscopically, the tumour presented the appearance of a leiomyoma, but each lamina of muscular tissue seemed to be separated from the adjacent one by young tissue, which presented all the appearance of a round-celled sarcoma. In other places, the muscular element was almost wholly replaced by sarcomatous tissue. This occurred in whatever part the tumour was examined, and it may best be described as a mixture of smooth muscle-fibres and round cells.

Neuromata. — This term should apply strictly to new growths composed of nerve-tissue, but it is customary to denote by this term almost any growth connected with a nerve-sheath, such as myxomata or fibromata, and it is convenient to denominate these forms "false" neuromata. Even in those troublesome little bodies, the painful subcutaneous tubercles, nerve-fibres have not been found.

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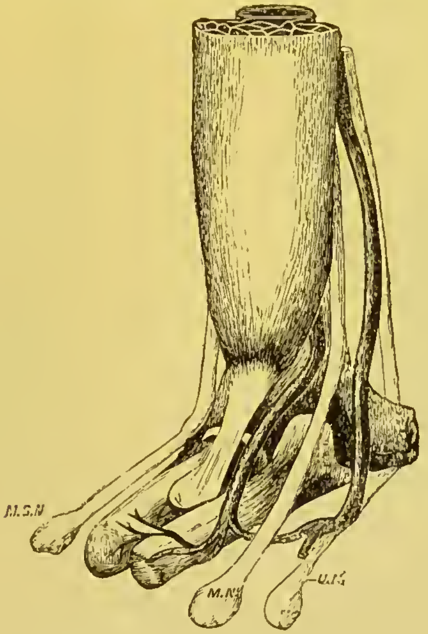
* Ziemssen's "Ency. of Med.," vol. x.

† "Path. Soc. Trans.," vol. viii., p. 287.

‡ *Ibid.*, vol. ix., p. 327.

The only growths in which new-formed nerve-fibres have been detected with any degree of certainty are those bulbous enlargements which arise on the proximal ends of divided nerves, or in cases of amputation.

Although in amputation-stumps the bulbs first formed contain new-formed nerve-fibres, yet later the nerve-tubules suffer atrophy, and the bulb consists wholly of fibrous tissue.



LEEDS & WEST-RIDING
MEDICO-CHIRURGICAL SOCIETY

FIG. 110.—STUMP OF FORE-ARM, THREE YEARS AFTER AMPUTATION. Showing bulbous enlargement of the ends of the median, ulnar, and musculo-spiral nerves.

Thus, in the stump of the fore-arm represented in Fig. 110, considerable enlargement has taken place at the ends of the median, musculo-spiral, and ulnar nerves. These bulbous enlargements of nerves may be occasionally seen in horses. On account of certain forms of incurable lameness, the veterinary surgeon divides and removes an inch or more of the plantar nerves, thus depriving the foot of sensation, and enabling the horse to work in spite of the diseased condition of the feet.

If the legs of a horse, which has been nerved some time previously, be examined, the proximal ends of the nerves cut in the operation may sometimes be detected as hard rounded knots through the skin. When dissected, and examined in detail, they are found in some cases to correspond in every way with the conditions of the nerves in an amputated stump in man. This is not universally true, indeed, in the majority of "nerved" horses, the formation of bulbs on the proximal ends of the divided nerves is an exception rather than a rule; there is reason to believe the more clumsily neurotomy is performed, the more likely is the operation to be followed by bulbing of the proximal end of the cut nerve. If the cut ends of the nerve reunite by means of new-formed nerve-fibres, or simply by means of fibrous tissue, an enlargement is sure to arise, as in Fig. 111.

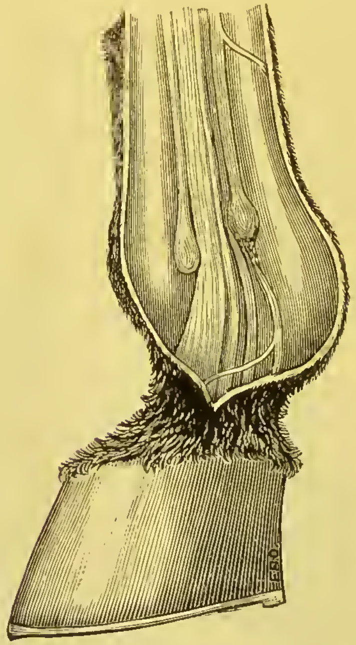


FIG. 111.—A BULB DEVELOPED ON THE PLANTAR NERVE OF A HORSE AFTER NEUROTOMY.

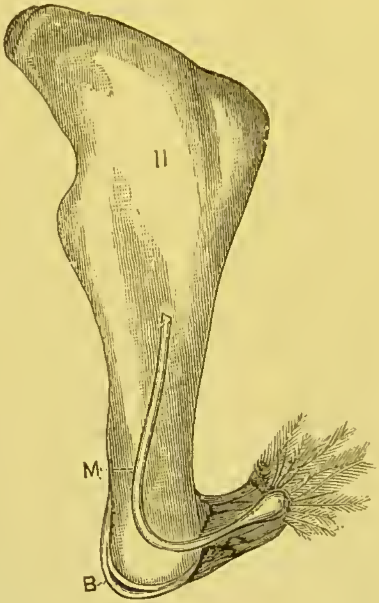


FIG. 112.—THE HUMERUS OF A VULTURE ELEVEN MONTHS AFTER AMPUTATION.

M, median nerve with a bulb; B, a bursa.

I have, on several occasions, had the opportunity of dissecting the stumps of limbs taken from wild animals whose legs have been caught in traps, shot, or bitten off by other animals, or the nerves cut designedly. The specimens include beavers, pigs, porcupines, frogs, rats, rabbits, dogs, cats, horses, and deer, but no neuromata could be detected, although in some of them the injury had occurred years before, except in the case of an Egyptian vulture. In this instance the humerus was broken, and necessitated amputation; the bird died more than a year afterwards with a large bulb on the median nerve (Fig. 112). In cats and dogs submitted to the operation of neurotomy, bulbing is by no means the universal condition of the proximal end of the divided nerve. If, however, the nerve be divided, and the proximal end irritated by applying a silk ligature to the nerve, or inserting a small fragment of wood to act as a foreign body, an enlargement is almost sure to follow. The best bulbs are produced by ligaturing a nerve "in continuity," and of all the vagus is the one that shows the conditions best.

Whether these facts will apply to the human subject is worth consideration. I have devoted some attention to the matter, and my limited experience induces me to believe that enlarged ends of nerves in amputations are more common where suppuration has been most profuse, and healing long delayed, or the nerves have become adherent to bone, or bound up in the cicatrix, and probably in some cases included in a ligature applied to an artery on the face of the stump. Neuromata do not attain sizes in proportion to the nerve to which they belong. Small sensory nerves in a stump may have relatively very large knots. Their size seems to have little influence on the pain felt in a stump, for in cases where this has been so severe as to necessitate re-amputation only small ones were present; in other instances exceedingly large bulbs existed without the manifestation of any unpleasant symptoms.

CHAPTER XVII.

SARCOMATA.

The term sarcomata is applied to a group of neoplasms which conform histologically to immature connective tissue—that is, the cellular constituents predominate over the intercellular substance. In this respect the structural details agree with the formative tissue of the embryo.

Sarcomata invariably arise in structures belonging to the histioid group, fibrous, cartilaginous, osseous, mucoid, lymphoid, or adipose tissue, and neuroglia. Hence they may occur in any part of the body, and are widely diffused throughout the sub-kingdom Vertebrata. They are usually very vascular, and are liable to secondary changes, mucoid and fatty degeneration, liquefaction, ulceration, and hæmorrhage.

Classification of the Sarcomata.

1. Round-celled.
    (*a*) Small round-celled.
    (*b*) Large round-celled.
    (*c*) Lympho-sarcoma.
2. Spindle-celled.
    (*a*) Large spindle-celled.
    (*b*) Small spindle-celled.
    (*c*) Chondro-sarcomata.
3. Gliomata.
4. Myeloid or Giant-celled
5. Melanotic Sarcomata.
6. Myxomatodes.
7. Alveolar Sarcomata.
8. Osteoid Sarcomata.
9. Psammomata.

1. *Round-celled Sarcomata.*—These are of simple structure, consisting almost entirely of round cells and vessels; the intercellular substance is very scanty. The cells are small and enclose a round or oval nucleus.

The museum of the College of Surgeons possesses a typical example of this kind of neoplasm in a bird. "It is a golden plover with a sarcoma lying beneath the skin of the breast, about an inch and a half in diameter; it is encapsuled, and on section is homogeneous. Under the microscope, the tissue appeared composed of round cells, each of which was enclosed within the meshes of a reticulum of fibrillar tissue."

Dr. Creighton has given a detailed account of a sero-sanguineous cyst which occurred in the neck of a retriever dog. The cystic interior held a considerable quantity of clear brownish fluid containing a large number of red corpuscles, leucocytes, and some large cells filled with yellow granules. The structure of the walls conformed to the type of a round-celled sarcoma.*

There seems to be a remarkably strong tendency on the part of sarcomatous tumours in dogs to become cystic. Mr. Sibley† has described a very good example of this sort which occurred in the breast of a bitch. The specimen, which is preserved in the museum of the Middlesex Hospital, is globular in form, and five inches in diameter. It consists of one large cyst with several smaller ones communicating with it. The main sac contained a pint and a half of tenacious brown-coloured fluid. Numerous villous-like growths project into the cavity; they are exceedingly delicate, and when the cyst is filled with fluid they float out and present a striking appearance.

Some of the loculi are almost filled with these villi, which, when examined microscopically, are seen to be composed of a delicate loop of blood-vessels, with a very small amount of connective tissue, covered superficially with cells, granular in appearance.

Having re-examined the walls of this tumour, I have come to the conclusion that we have here to deal with a round-celled sarcoma, such as those described above.

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* "Journal of Anatomy and Physiology," vol. xiv., p. 292.

† "Path. Soc. Trans.," vol. lx., p. 460.

The "Brit. Med. Journal" for 1883* contains two accounts of round-celled sarcomata in birds. A fowl, one year and a half old, presented a growth on the neck, immediately below the beak. It finally attained the size of a cricket ball, and weighed nearly seven ounces. The disease recurred two months after removal. Histologically it was composed of round cells in a fibrillated matrix. The cells were equal in size to a red blood-corpuscle.

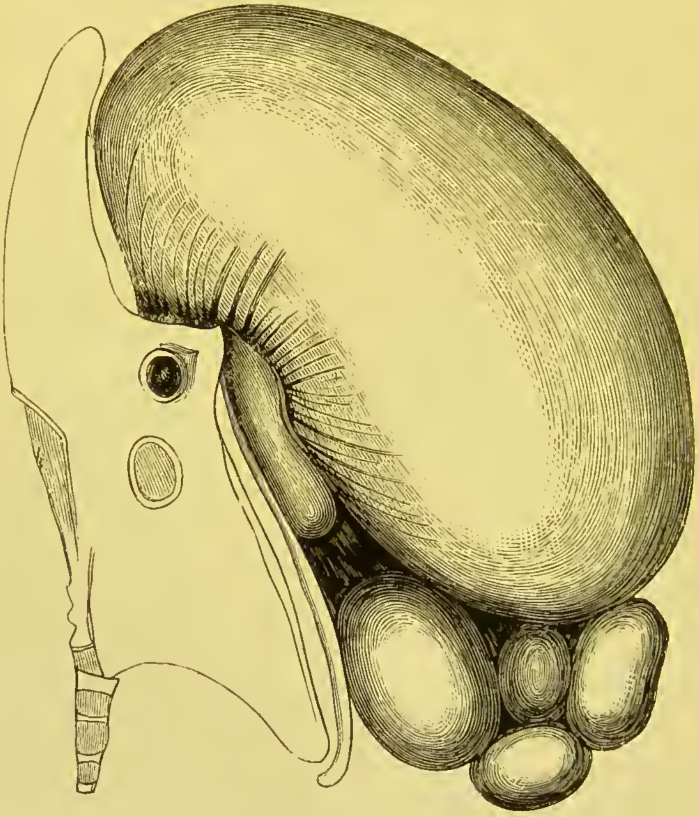

FIG. 113.—THE PELVIS OF A HEN WITH A SARCOMA WEIGHING 18 OUNCES DEVELOPED IN ITS OVARY.

The second case, also in a common fowl, grew around the margin of the left eye, forming a thick prominent ring. There was also a growth the size of a pigeon's egg in the lower third of the neck. The sarcomata, which were made up almost entirely of small round cells with a few spindle-shaped ones, formed an infiltrating mass between the layers of the subcutaneous tissue.

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* Rep. by Mr. Hathaway, examined by Mr. Bowlby.

I have also seen sections of a sarcoma removed from the wing of a Javan sparrow, which in every way conformed to the type of structure described in the two preceding cases.

The large growth represented in Fig. 113, found in connection with the ovary of a hen, was apparently a round-celled sarcoma.

Lympho-sarcomata.—These are a variety of the small round-celled sarcomata. Structurally they resemble lymphatic glands, being made up of a reticular stroma with ramifying cells (adenoid tissue) containing round cells in the meshes of the stroma. These growths increase rapidly, and give rise to secondary formations.

Mr. Eve* reported a case of this nature which occurred in a dasyure (a marsupial from Van Diemen's Land). The tumour consisted of an agglomeration of enlarged and coalesced lymphatic glands, removed from the abdomen. The spleen was connected with the upper part of the growth, which equalled two-thirds the weight of the animal.

The tumour consisted of closely-aggregated round cells resembling lymph-corpuscles; its vessels were abundant and had no proper wall. Some rounded masses, one to two inches in diameter, were found in the liver, lung, and colon.

A similar condition came under my notice also in a dasyure. In this example the adrenals were affected by the growth. Lympho-sarcomatous masses are frequently found in the horse, associated with the glands of the mesentery and those of the lumbar set. In some of these cases the morbid mass weighs many pounds. These growths disseminate themselves, and are therefore to be regarded as malignant; secondary deposits are most frequently seen in the liver and spleen. In the latter organ they vary in size from a hazel nut to a deposit as large as an orange; usually they are of a greyish-white colour, and of moderate consistence. The nodules in the liver are of smaller size and disseminated through the organ. They do not differ histologically from the primary masses.

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* "Path. Soc. Trans.," vol. xxxiii., p. 432.

Lympho-sarcomata occur in horses, frequently in the lumbar glands immediately around the anterior mesenteric artery, in the mediastinum, and in the neck. Calcific deposits are not uncommon in large tumours of this kind. It is not unlikely that the frequency of lymphoid masses in the neighbourhood of the anterior mesenteric artery in the horse is to be accounted for by the frequent presence of the parasite strongylus armatus in the fibrous tissue of the tunica adventitia of the aorta, cœliac axis, etc., acting as an irritant.

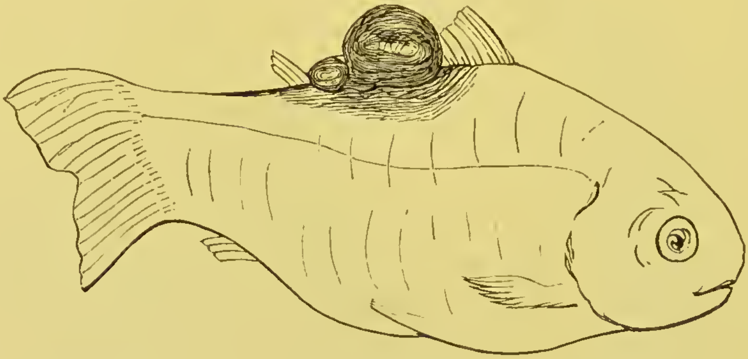

FIG. 114.—A GOLDEN CARP WITH A SPINDLE-CELLED SARCOMA IN CONNECTION WITH ITS DORSAL FIN.

Lympho-sarcomata occasionally grow in the mediastinum of monkeys, and invade the lungs or pericardium.

Spindle-celled Sarcomata.—In this variety the predominating shape of the cells is spindle-form. Neoplasms of this type are, as a rule, much firmer than the round-celled variety.

Dr. Creighton has reported a typical case of this variety, which was removed from the head of a dog at the Brown Institution, July, 1875.

There was a cavity in the interior of the growth filled with a clear brown fluid, which contained a number of cells of very large size, which exhibited amœboid movement (the fluid was examined whilst still warm). The interior of the cavity was in places crossed by trabeculæ, rounded in shape. and about a line or two in thickness. The structure of the walls of the growth was that of a spindle-celled sarcoma.

Growths of this kind occur with tolerable frequency in the dog, and are nearly always situated in the subcutaneous tissue.

Even fish are subject to spindle-celled sarcomata. The group is well illustrated by specimens in the museum of the Royal College of Surgeons, London. A golden carp with a tumour growing from the posterior border of the dorsal fin is shown in Fig. 114. The morbid growth is about the dimension of a filbert nut; it has been examined microscopically, and found to exhibit the characters of this variety of neoplasm.

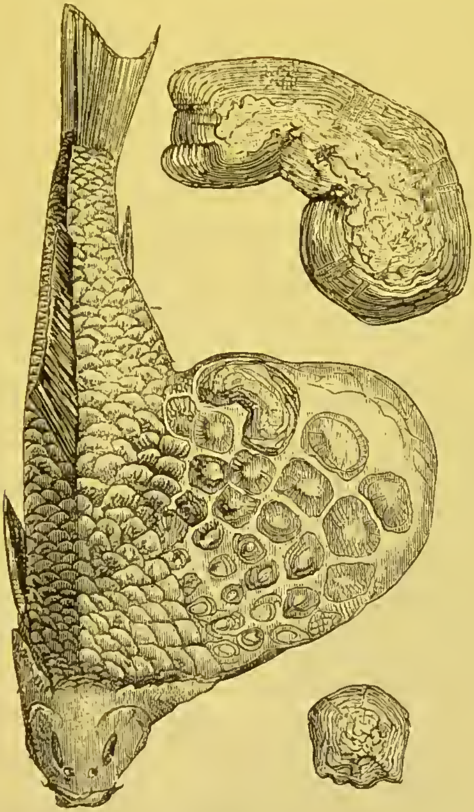

FIG. 115.—A ROACH WITH A SPINDLE-CELLED SARCOMA GROWING FROM ITS SIDE.

The lower figure represents the natural size of the scale, whilst the upper one shows the large size of the scales over the tumour.

The specimen represented in Fig. 115 is also preserved in the museum:—

It is a large spindle-celled sarcoma growing from the side of a roach. In this case the scales which cover the tumour are three times broader than those over the healthy part of the neoplasm. It would seem as if the matrix-tissue of the scales was expanded by the rapid enlargement of the growth.

There is one very curious feature connected with the spindle-celled variety of sarcomata which must be considered, and that is their disposition to form cartilage, especially when occurring in the parotid region and testis. Mr. Butlin* points out that cartilage occurs in greater or less quantities in half the number of these cases. One of the most interesting features in these "Lectures" of Mr. Butlin is his endeavour to separate the cartilage-containing sarcomata of the testis from enchondromata in general, and to show that they are really to be regarded as chondrifying sarcomata. This view of these growths is very important, for it explains why so many of these tumours of the testis exhibit malignant tendencies, a condition of things certainly not the rule in other parts.

Growths similar in character affect the testes of animals, as the following account proves:—

The "Veterinarian" for 1850 contains a well-reported case of an ossifying enchondroma connected with the testicle of a horse, by Joseph Gamgee. The testis was removed from a four-year-old horse. The animal was the sire of several colts, and did not suffer any particular inconvenience from the presence of the diseased organ. The gland nowhere presented its normal structure, the tissue being soft, of a red colour, and ill-defined, and was connected with a tumour of moderate hardness, about the size of an orange.

The growth was of pale yellow colour when seen in section, finely and irregularly lobulated, and contained three cysts; cartilage was visible in the centre of the cut surface, and could be felt extending into its substance. On microscopic examination, the neoplasm was found to contain fat, fibrous tissue, cartilage, and bone.

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* "Sarcoma and Carcinoma," 1882.

When critically examined, the cartilage-cells, as they approached the surface, were found to become much flattened, and to degenerate into, or at any rate to become intimately blended with, the adjacent fibrous tissue and fat. The matrix appeared in some situations homogeneous and transparent, in others granular, and at wide intervals a few delicate fibres might be seen winding their course between the cells. A transverse section of the bone exhibited imperfectly the ordinary structure of osseous tissue.

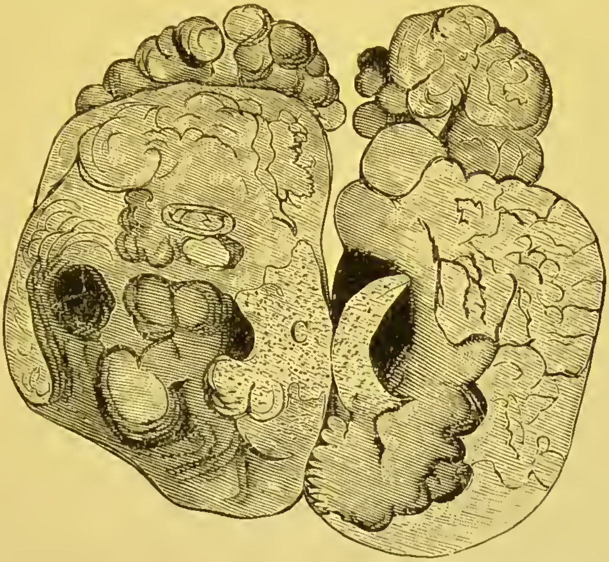

Fig. 116.—Sarcoma containing Cartilage, C, connected with the Testicle of a Horse. (After Gamgee.)

If the details of this case be compared with the description of similar tumours met with in the testis of man, and be criticised in the same manner in which Mr. Butlin has discussed them in his "Lectures," there will remain little doubt that this neoplasm belongs to the same category.

It is possible that the following case, reported by Virchow, is of sarcomatous nature :—

A bitch had a large ossifying enchondroma of the mamma; there was also a large tumour in the omentum, softened in the centre after the fashion of a cyst, and filled with liquid.

There were numbers of small nodules in the lungs, on th pleura, and in the mediastinum. Many of the nodules i the lung had spread by way of lymphatics, so as to communicate with neighbouring ones, and formed a kind of networ throughout the lung-tissue.

Histologically, these nodules were composed of fibrou hyaline cartilage which had undergone calcification in th centre. The masses in the lymphatic vessels had commenced to chondrify in the middle; at the periphery o these deposits there were collected groups of cells, but n intercellular substance.

To any one acquainted with the fundamental facts o embryology, it is perfectly comprehensible that a spindle celled sarcoma should contain cartilage. In the normal cours of development, the cells of the mesoblast in those situa tions where bone is to be formed, will be found to assume fusiform shape, and to become closely aggregated togethe and form a model of the cartilage which is to be th forerunner of the bone. These close aggregations of th spindle cells form the well-known "prochondral" tissue o morphologists, which, later, is replaced by cartilage. In section through the carpus of a human embryo, betwee the second and third months, all these stages may be easil studied, and exactly recall the microscopical appearances o a chondrifying sarcoma.

Gliomata.—Gliomata are neoplasms formed on the type o neuroglia, the delicate connective tissue found in the centr nervous system. Histologically, gliomata are composed of fibrillated intercellular substance, the fibrils of which, whe isolated by teasing, will be found exceedingly slender. Dott in this matrix are the cells with a round or slightly ov nucleus; the cells, in teased preparations from fresh specimen will be found to possess ramifying processes.

Gliomata often exhibit patches of hæmorrhage softenin and caseation. In the human subject they are locall malignant, and have marked infiltrating propensities, b do not often reproduce themselves in internal organs.

Gliomatous growths are not by any means common animals. A very marked case came under my notice in the right eye of a bonnet-monkey, aged about eight months. The eyeball was much enlarged, there was considerable proptosis, the cornea being bulged forward in a curious fashion, and there was œdema of the eyelids. The morbid mass entirely filled the interior of the globe, but in no spot had it broken through the tunics. The lens was opaque. The lymphatic glands were not affected. On making a section through the globe, spots of hæmorrhage and caseation were visible. Under the microscope, in the best preserved portions of the tumour, the structure typical of a glioma was distinctly obvious. The cells were small, for the most part round, and very numerous.

The museum of Guy's Hospital contains, amongst its specimens of comparative pathology, two examples of sarcomatous tumour of the eyeball, one affecting the retina of a horse, the other that of a sheep. Through the kindness of the curator, Dr. Goodhart, I have been able to examine the histological characters of these tumours. The growth in the eyeball of the horse is a typical glioma, and the specimen shows admirably the connection between the tumour and the retina, notwithstanding the fact that it had been in the museum certainly thirty-five years, and how long before that time it is impossible accurately to determine.

In the case of the sheep, the character of the growth was not so definite. In parts it looks like a glioma; in others it resembles melanotic sarcoma.

Myeloid Sarcomata.—This variety of connective-tissue neoplasms is characterized by the occurrence in large numbers, of giant-cells, the peculiar multinuclear bodies found in the normal condition in the medulla of a long bone. It must be admitted that very many sarcomata, springing from, or growing in the neighbourhood of bone, contain myeloid cells, yet do not belong to this category. A good example of this kind of growth is an osteoid tumour on the leg of a rat, described on p. 296.

Butlin lays down the following definition for a myeloid sarcoma:—"The giant-cells should constitute about fourfifths of the bulk of the growth, or be present in such numbers that they decidedly affect the aspect of the tumour, colouring it a maroon red."

Tumours corresponding to this character must be very rare in animals. I have never met with any, or found any examples recorded.

Melanotic Sarcoma.—This class comprises sarcomatous formations which contain deposits of pigment. The pigment, which may be either black or brown, may be partly in the tumour-cells, partly in the fibrous matrix and walls of the vessels. The pigment is usually in the form of amorphous granules. Morbid growths of this kind are especially frequent among white horses, oxen, and dogs.

Hunter removed one of these tumours, and his prowess in this direction is attested by the specimen now in the Hunterian Museum. It is thus described in the catalogue :—

"Section of a melanotic tumour removed from the neck of a horse. It is deep black throughout, moderately firm, lobulated, and on its cut surface rather shreddy."

Hunter's account of the case is given in the catalogue, from which the following selection is made :—

"The tumour was on the near side of the neck; lay immediately on the inside of the jugular vein, where they commonly bleed; the vein was plainly seen passing over it. It was about eight or ten inches long, in the direction of the neck, and about four or five inches thick. It was loose, not attached but by loose cellular membrane.

"The tumour was of a very dark colour, and when cut into and squeezed, a black fluid, exactly like ink, came out on the cut surface. It blackened the water it was steeped in for a considerable time" (*Hunterian MS.*)

The animal did not survive the operation.

In the same magnificent collection are two other examples of melanotic sarcomata affecting the tails of horses; also the udder of an almost white cow which contains a tumour about three inches in its long diameter, and uniformly black. The skin of the udder is mottled with numerous pigmented blotches.

Virchow has collected facts, and recorded them in his great work on "Tumours," regarding the especial liability of white horses to melanotic sarcomata. The neighbourhood of the anus or tail are favourite situations for these masses. He has met with, and examined tumours from both these situations, and found them to exhibit sarcomatous structure; but the cells are fewer than in man. The growths on the tail form large excrescences, like mushrooms, with little disposition to ulceration or metastasis; but later writers, especially Cornil and Trasbot, show that secondary deposition is the rule. Virchow states that Brugnone appears to have been the first to notice this affection in horses, under the name of hæmorrhoids. Noack, in 1826, described the affection, and gives some figures illustrating the condition in white horses.

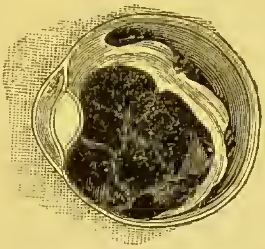

FIG. 117.—A MELANOTIC SARCOMA AFFECTING THE EYE.

Carswell gives some beautiful illustrations of melanotic tumours in horses, and states that "the largest masses have been found in the loose cellular tissue, and have been known to weigh from twenty to thirty and even forty pounds."

Gluge describes the occurrence of these growths in horses (white or grey), rabbits, rats, mice, cows, asses, mules, and cats, and mentions that Otto has seen the disease in a stag. Gluge found no structural difference in the growths in the horse or man. In animals it affected chiefly the anus and reproductive organs.

Lebert gives some excellent drawings of melanosis in the horse, having seen the pigmented masses occupy the surface of the lungs and pericardium of the shape and size of grapes.

The spleen and kidneys also contained melanotic tumours.

and a certain number existed in the heart. The masses had a sepia tint. Lebert speaks of having many times seen melanotic tumours in horses. Barlow has made the following remarks on the subject:—

"Melanosis among the lower animals is almost exclusively confined to grey horses. The disease often appears locally at first, and manifests itself on the external parts of the body covered by dark-coloured skin, as the under surface of the tail, anus, and margins of the eyelids. When of longer duration, many of the internal organs, but more especially the mesentery, become involved, and instances have been seen where the voluntary muscles have been extensively affected. It does not evince any of those characters which in the human subject are taken as indications of malignant disease; on the contrary, unless exposed to mechanical injury, it does not ulcerate or soften, and when a tumour is freely cut into and partly removed, the portion still remaining will readily heal. Professor Dick once amputated a horse's tail as high up as its second vertebral segment. The melanotic mass weighed fifty-six pounds. In the operation a large amount of diseased tissue was left in connection with the anus and croup. The cut surface healed as readily, so far as could be judged, in quite as short a time as an incision of similar extent would have done if made in completely healthy tissue."

By far the most elaborate investigation of this subject has been made by Cornil and Trasbot.

These authors divide the melanotic tumours of horses into two classes—melanotic fibromata* and melanotic sarcomata.

In this section the sarcomata only will be considered. It is the most common neoplasm in the horse, and has a remarkable tendency to generalization. The primary tumours are almost invariably developed in the subcutaneous tissue of the anus (Fig. 118), the under surface of the tail, the external organs of generation, the sheath in the male, or the mamma in the female. Out of thirty-seven observations all but five commenced in these regions. The age of the horses varied from four to seventeen years; the prevailing colour was white or grey—only two were black.

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* *Vide* p. 246.

The tumours are always very small at the commencement, acquire with time dimensions varying from a pea to a man's fist. Usually their number is considerable, united or adherent, forming tuberous masses, and continuous with the neighbouring parts by connective tissue. At the commencement they are situated exclusively in the skin and subcutaneous tissue. Superficially their colour is slate-grey, but completely black on section; a liquid mass may be squeezed out by compression, having the colour of sepia. In consistence they are sometimes as soft as a medullary cancer; in other cases they may be as hard as scirrhus, the difference in density varying with the proportion of fibrous tissue.

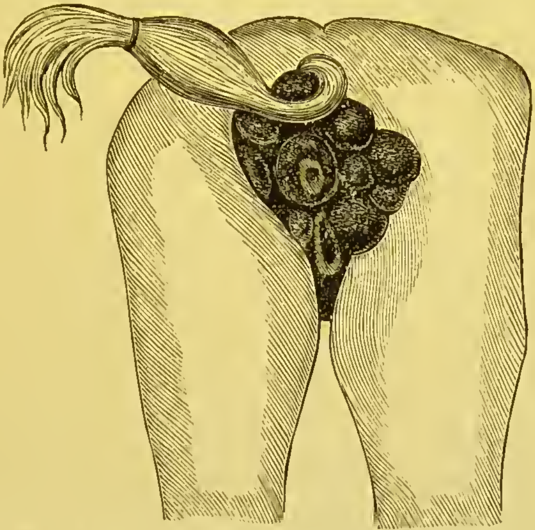

FIG. 118.—MELANOTIC SARCOMA AROUND THE ANUS OF A MARE. (After Cornil and Trasbot.*)

The centre of these masses is softer than the periphery, sometimes formed into actual cavities. Occasionally they ulcerate.

Histologically, the tumours are composed of parallel fasciculi of fibrous tissue, with cells more or less fusiform in shape containing pigment. In the broken-down central portions of the growths the cells are of all shapes and sizes, branching, fusiform, or spheroidal, containing black granules. In the older and most deeply-coloured portions of the tumours the elements adhere more or less to one another, and approach somewhat a spherical form, but they always maintain the same disposition and characters (Fig. 119).

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* Noack gives a similar illustration.

Usually these neoplasms grow slowly; they may remain passive many years, then take on active growth, but as a rule they slowly increase throughout the animal's lifetime.

Ulceration.—The tumours often soften in some part or other, form open ulcers, hideous and repulsive, and discharge a dirty black liquid. Sometimes these growths when cut into will cicatrize. In one curious case, which Cornil and Trasbot followed for five years, a white horse possessed a large melanotic mass, which would ulcerate and remain open for several weeks in spring.

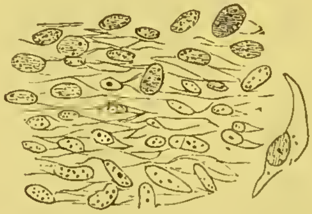

FIG. 119.—MICROSCOPICAL CHARACTERS OF A MELANOTIC SARCOMA.

The Secondary Tumours.—These may develop in every organ, or in almost every situation where cellular tissue is loose and abundant—the pelvic cavity, the entrance to the thorax, lymphatic glands, and muscles. The secondary nodules occur also in the liver, spleen, lungs, and suprarenal capsules. They affect the serous membranes, the brain and spinal cord, rarely the bones, and exceptionally the kidney, the substance of the heart, and the mucous membranes. In the connective tissue they may acquire a considerable size, weighing as much as eight or even twenty pounds. In form they may be spheroidal, elongated, or fusiform, but always with tuberous rounded extremities. They may surround vessels and nerves, and thus interfere with their functions. In structure they agree with the primary tumour.

The lymphatic glands are affected always, and present a slate-grey colour superficially, but are entirely black on section. They are hard, and resistent to cutting instruments. The pigment at first affects only the connective tissue of the glands, but later it invades their substance.

Next to the glands the muscles are most frequently affected by the dissemination of the growth, in the form of very small discoid and lenticular masses developed on the surface and in the intermuscular fasciculi. The deposits are sometimes united by pigmented strands of connective tissue, so that on section a muscle bears a resemblance to a piece of mahogany.

In the serous membranes small lenticular nodules are dotted over the surface, often of the size of a nut, and extend into the subserous connective tissue.

The spleen is affected with extreme frequency, sometimes to such an extent that its size is doubled; in some cases it has weighed thirty or forty pounds. In the liver, secondary masses are common, and of very large size. In the lungs, the tumours are generally globular in form, varying in size from a nut to an ordinary apple. When occurring in the cranium or spinal cord, they are intimately associated with the contained organs. They have been seen in the spinal canal of a mule. Any organ in the body is liable to be secondarily affected.

There is good reason for believing that the disease is not contagious. Cornil and Trasbot have made a great number of experiments—inoculations, grafts in the subcutaneous tissue, injections in the veins with liquid taken from the tumours in the living animals, or immediately after their removal. The experiments were tried on horses and dogs, without result. The grafts in horses always set up suppuration, and were expelled. In the dog, they remained surrounded by a zone of induration, but did not farther develop.

After a careful perusal of the elaborate article of Cornil and Trasbot, I have sought out a great number of cases incidentally recorded in veterinary literature; they go to substantiate the views of these writers.

The following list includes the chief references on this subject:—

Gohier: "Mém. et Observ. sur la Chir. et la Méd. Vétér.," Lyons, 1813, tome i., p. 324. C. A. Noack: "Diss. inaug. de melanosis cum in hominibus, tum in equis obveniente," Lip., 1826, tab. 1—11. Carswell: "Path. Anatomy" (Melanoma, pl. i.), 1838. Lebert: "Traité d'Anat. Path.," tome i., pp. 116, 121, pl. xv., 1857-61. Gluge: "Atlas der Path. Anat.," liv. iii., taf. i., 1750. Barlow: "Ed. Monthly Journal," Aug., 1851. Cornil et Trasbot: "De la Mélanose," 1868. Virchow: "Tumours." (The various volumes of the "Veterinarian" contain numerous reports of individual cases of melanosis; some are of great interest.)

In man, melanotic sarcomata occur most frequently in connection with the choroid coat of the eye, the skin, and especially in pigmented moles. They rarely attain large proportions, and are more malignant than would seem to be the case in grey horses.

Myxomatodes.— Sarcomata are prone to undergo mucoid changes in different parts of their substance; such a change may even affect an entire tumour. Partially degenerate sarcomata are described as myxomatodes.

Dr. Creighton * has published two admirable examples of this peculiar form of tumour. Both tumours were removed from dogs at the Brown Institution, London, 1875.

The first growth was situated immediately beneath the skin of the neck, a piece of the integument being removed with it. The interior was cystic, and contained a clear fluid, brownish in colour, and of mucous consistence. The entire growth was three inches in diameter, the cyst-walls being in some places more than an inch in thickness. Elongated narrow spaces were found at several places in the cyst-wall. The mass of the tumour was soft and almost gelatinous. The second case was removed from the hip; it lay close under the skin. It was not cystic, but its texture was mobile and fluctuating. It was definitely rounded, flattened on its lower surface, and was about two inches in diameter. The minute structure was the same in both tumours—that of mucous sarcoma or myxomatodes.

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* "Journal of Anatomy and Physiology," vol. xiv., p. 292.

The cells were large, about three times the diameter of a leucocyte, and somewhat flattened on one or more sides. There was a central nucleus, and a white zone of cell-substance, which is especially granular at the periphery.

The intermediate ground-substance in the cystic case was granular after the tumour had been preserved. In the case from the hip, the intercellular substance was made up of fibrils, or of thicker homogeneous bundles.

Many, perhaps most, of the sarcomata which occur in man, and attain to any size, present in some part or other of their bulk, patches of tissue undergoing this peculiar mucoid change. In speaking of round-celled sarcomata, it was stated that when they occur in dogs they commonly present a cystic interior, and there are strong reasons for believing that mucoid degenerations of these new growths occur with greater frequency in dogs than in any other animal. The cause at present is not very obvious.

Alveolar Sarcomata.—This peculiar variety of sarcomata strongly resembles, in its histological features, the carcinomata. These neoplasms consist in the aggregation of cells into groups, separated by septa of fibrous tissue. The cells are of the round variety; they are usually of large size, and, according to some authors, it is possible to distinguish a delicate reticulum between the cells. It is in this particular form of tumour that the classification of new growths, based on histological grounds alone, fails, for it is impossible to be absolutely certain, from the microscopical details alone, whether we are dealing with a cancer or an alveolar sarcoma, so closely is the glandular type mimicked. Hence we are driven to ascertain its mode of genesis, whether from connective tissue or epithelial multiplication.

The true relationship between alveolar sarcoma and medullary carcinoma is an interesting and important question. The tumours of the testis present us with very valuable material in this respect, and it is really a doubtful question whether we have reliable indications by which we can state positively that a given tumour of the testis is a sarcoma or carcinoma. Until some decisive investigation is made as to the origin of the epithelial lining of the seminiferous tubules, the question must remain *in statu quo.* There are good grounds for believing that the epithelium of the reproductive organs is a derivative of the hypoblast (see page 313).

Osteo-Sarcomata.—This is a variety of sarcoma in which the growth becomes calcified, or may even become converted into true bone. The primary seat is almost exclusively in connection with bone, arising either from the periosteum or the medulla. Examined microscopically, they will be found composed in places of calcified tissue or imperfectly-formed bone, containing in its trabecular meshwork round spindle-shaped cells, or the giant-cells so characteristic of myeloid sarcomata. In Fig. 120 an example of this variety of tumour is represented, which grew from the leg of a rat. It is of considerable size, and contains all the variety of cells just enumerated, besides a large quantity of pigment scattered throughout the growth.

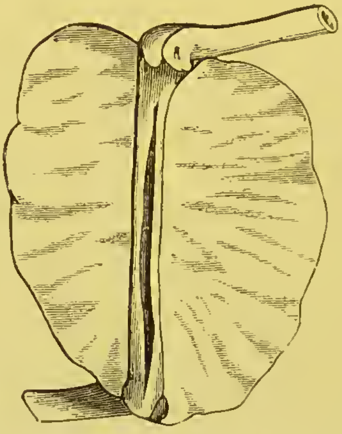

FIG. 120.—OSTEO-SARCOMA ON THE LEG OF A RAT.

An excellent example of osteo-sarcoma came under notice in the femur of a frog, possessing all the histological characters of the sarcoma in the rat. A third specimen was examined in the femur of a nestling swallow.

Psammomata.—The name psammoma has been applied to a curious form of neoplasm occasionally found attached to the membranes of the brain and spinal cord. Its distinguishing feature is the presence of a gritty substance, acervulus cerebri or brain-sand, such as normally exists in the pineal gland; indeed, the structure of this appendage of the cerebrum may be taken as the physiological type of the psammoma. The sabulous matter consists of phosphate and carbonate of lime, with a little phosphate of magnesia and ammonia, combined with animal matter. Besides the pineal gland, it may often be detected in the choroid plexuses, dura mater, arachnoid, and Pacchionian bodies.

Virchow distinguishes two kinds of psammomata.

(1) The sand occupies the interior of cavities, which are formed by fasciculi of fibrous tissue, in the form of compact cylinders or pyriform masses.

(2) In this form the sand is diffused through the tumour as minute rounded or elliptical corpuscles. These grains, when isolated, may show a concentric arrangement.

Virchow insists on the distinction of these gritty particles from corpora amylacea, by their structure, chemical characters, size, and hardness.

Typical examples of these tumours occurring in man have been placed on record, and illustrated by careful drawings, by Drs. Wilks,* Cayley,† Dreschfeld,‡ and J. Hutchinson, jun.§

There is very good reason to believe that the term psammoma has only a generic signification, and that calcification occurs in the cells of neoplasms presenting widely different histological characters, as sarcomata and epitheliomata. Calcareous deposits have been found in tumours of the orbit, the mamma, and the ovary. Although growths of this kind, sufficiently large to give rise to symptoms, are rare in the human subject, as for the most part to be regarded as pathological curiosities, yet they occur frequently in the horse, to judge from the number of reported cases to be found in the pages of the "Veterinarian." The most frequent situation of these tumours in the horse, as in man, is the choroid plexuses, in which situation they are usually symmetrical. They vary in size from a small pea to that of a hen's egg. Even when of large size they rarely cause symptoms to indicate their presence, probably on account of their very slow growth; but occasionally they have been known to give rise to severe symptoms, leading to the death of the animal.

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* "Path. Soc. Trans.," 1855.

† *Ibid.*, 1865.

‡ "Journ. Anat. and Phys.," vol. xiv., p. 337.

§ "Path. Soc. Trans.," 1882.

The largest psammoma I have found recorded, is one by Lassaigne, in the "Ann. Chem. et Phar.," lxii., 292. The mass, as large as a hen's egg, was found in the right lateral ventricle of an old horse; it weighed fourteen drachms, and gave rise to no symptoms. It was composed of cholesterine, 58; membrane and albuminous matter, 39·5; and sub-phosphate of lime, 2·5.

The presence of cholesterine in tumours connected with the choroid plexuses is well attested.

In 1854 Leblanc made a communication to the Imperial and Central Society of Veterinary Medicine, Paris, on the subject of tumours of the brain.* He referred to a case of enlargement of both choroid plexuses to fifteen times their normal size. Each mass contained a considerable quantity of small nacreous bodies known to be composed chiefly of cholesterine, which was arranged in the form of crystalline plates, like the leaves of a book; some phosphate of lime was also deposited in a crystalline form.

Pearly masses of cholesterine have also been detected in the tissue of the choroid plexus by Bouley.

Leblanc believes, but on insufficient grounds, that this condition of the plexuses is associated with an abundant accumulation of serous fluid in the ventricles.

Accumulations of cholesterine have been seen on the choroid plexus of the fourth ventricle of a mare, in monilliform masses, each bead having the characteristic lustre of cholesterine. The animal was liable to sudden attacks of excitement when standing in the stable as well as at work.

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* *Vide* "Veterinarian," 1855.

A careful and exact account of these bodies is given by John Gamgee, in the "Veterinarian," 1852.

He shows most conclusively that cholesterine enters largely into their composition, as well as small spherical bodies composed of phosphate of lime.

Gamgee also states that Dr. Bennet describes the mode of formation of these bodies in the choroid plexuses in the following manner:—

"At first there seems to be deposited a quantity of mineral granules in round or oval patches, more or less large. As these become more numerous, a clear centre, composed of transparent homogeneous mineral substance may be seen, which gradually extends to the circumference, until the whole presents a uniform mass. They are in many respects very similar to the mineral concretions so common in the prostate gland."

After comparing the descriptions of a large number of these curious tumours from the brains of horses, with those occurring in a corresponding situation in the ventricles of the brain of human beings, the only distinction that can be drawn between them is, that in the horse cholesterine and phosphate of lime are present, the former in considerable quantity, whereas in man phosphate and carbonate of lime make up the earthy matter, cholesterine being absent.

CHAPTER XVIII.

ETIOLOGY OF MESOBLASTIC NEOPLASMS.

Few subjects have exercised the ingenuity of pathologists more than the etiology of neoplasms. It is not necessary to recapitulate the various theories which from time to time have found adherents. There is no exclusive theory which can explain the causation and mode of origin of all known neoplasms; indeed, the three groups require separate consideration. The mesoblastic and teratoid groups arise in a manner entirely different to those of epiblastic or hypoblastic origin; indeed, the difference in the mode of genesis sanctions the classification adopted.

Remembering also that in dealing with the subject of neoplasms in this work, we are extending our view of the matter throughout the whole animal kingdom, it becomes necessary to adopt some such mode of classification as shall be of universal application. The plan which suggested itself was the embryonic one; long ago Huxley showed that the two membranes of the body-wall of the medusæ, the *endoderm* and *ectoderm* of Allman, are comparable to the hypo- and epiblastic layers of the vertebrate blastoderm.

This conception became an established fact when Kowalevsky proved, by his valuable and brilliant researches on amphioxus, annelids, ascidians, and many others, that in these forms the two layers were developed in fundamentally the same way, and proved their homology through the various types which he investigated. These discoveries also afforded us reliable means whereby the homologies of various organs and tissues in animals widely different could be determined.

Although various lacunæ exist in our knowledge as to the actual layer from which a few of the tissues are derived, nevertheless, regarding the more important ones our knowledge is sufficiently exact to enable the method to be used with very considerable advantage. The various points on which differences of opinion exist as to the origin of any particular tissue will mainly affect the epithelial growths, and the subject will be fully discussed when we come to deal with the etiology of that important group of new formations.

Cohnheim's theory, which ascribes the origin of neoplasms to persistent germinal rudiments, is of all hypotheses that which has most to recommend it, if the term tumour be used in its most restricted sense.

In the course of this chapter the expression "germinal rudiment" will be used in a more extended sense than that in which Cohnheim employed it.

At the outset it will be well to ask the questions, Do germs such as this theory demands, exist? and have we any evidence to show that they may become tumours?

That true cysts originate in functionless ducts and tubules is a fact which no one can dispute; for example, the cystic dilatation of the tubules comprising the parovarium, epoophoron, paradidymis, and duct of Gartner in man and animals. In chapter xii. an endeavour was made to demonstrate the origin of other examples of cysts in frogs, toads, birds, etc., from rudimentary ducts. If, then, we receive without demur the origin of cystic structures from functionless tubular organs, or cyst-germs we may call them, why should the origin of solid tumours from rudiments be doubted, especially if such untransformed tracts of tissues can be demonstrated unequivocally to be heteroplastic in their nature?

Of course it is far easier to demonstrate the origin of cysts from pre-existing germs than in the case of neoplasms it is ever likely to be. Nevertheless, we are certainly able to show that in the regions where particular tumours are more prone to occur, there is embryological testimony to explain why they occur there. And epithelioma on a lip is what would be expected; but a similar growth starting in the midst of the brain would be incomprehensible. In the same way may we regard the existence of a piece of cartilage in the midst of the shaft of a long bone in a boy, aged five years, as cartilage in the wrong place, yet such was the case in the section of the lower end of the femur, represented in Fig. 121.

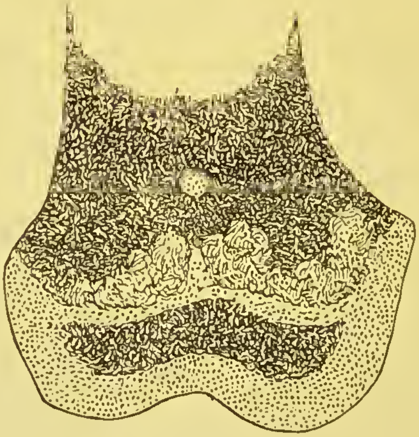

FIG. 121.—RICKETY EPIPHYSIS OF FEMUR WITH A CARTILAGE-ISLAND.

The existence of cartilage-islands has now been known for some years, and Virchow showed that such untransformed pieces of cartilages may be regarded as tumour-germs, and later in life, if circumstances be favourable, may actually develop into neoplasms. When dealing with enchondromata (Chapter xvi., p. 252) other instances of cartilage islets in association with rickety changes were described.

Not only do these examples teach us, in the most positive terms, that embryonic cartilage rudiments exist, but they teach us something of the evolution of neoplasms. In the fact that at an early age our skull is mainly cartilage we agree with the sharks, rays, and those fish (see Fig. 122) whose skulls never advance in development higher than cartilage impregnated with salts of lime; as we advance to bony fish and amphibians, the overlying bones gradually bring about absorption of the cartilage in places, but much exists throughout the lifetime of the animal, and in the skulls of mammals, even the highest, we find traces in the adult of this important matrix-tissue so characteristic of its embryonic condition: yet, in spite of this, some men cavil, and say embryonic rudiments cannot exist in the adult. Surely they are not in earnest.

In the same way the developmental history of every mammalian skull tells the same tale. If at the tenth week of intra-uterine life of the human embryo all the investing tissues be carefully removed, the base of the skull and face will have the appearance shown in Fig. 123, A, B, C, and D, where hyaline cartilage exists in abundance. It is unnecessary to enter into a detailed account of the way in which this chondral tissue is replaced or transformed; but it is familiar to every one that in the adult skull, cartilage plays a very insignificant part. I shall, however, enter into a careful account of two particular portions of the cranium which are the most frequent spots for the existence of these belated rudiments; they are the regions of the skull known as the asterion, and the parts about the nasal fossæ. It will be

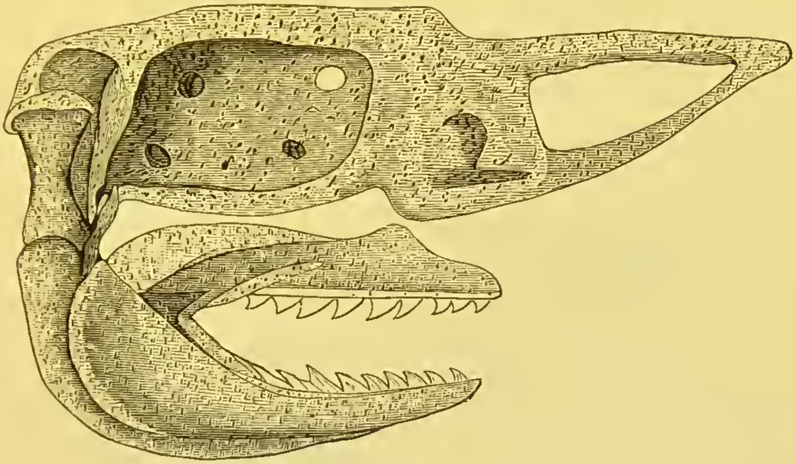
FIG. 122.—THE CARTILAGINOUS SKULL OF A SHARK, *MUSTELUS.*

readily seen, on reference to Fig. 124, that a region of hyaline cartilage exists in the fœtal skull posterior to the tympanic annulus. The figure was taken from the skull of a fœtus at about the fifth month, the cartilage in question being a remnant of the primordial chondro-cranium. As ossification proceeds, this tract of cartilage is invaded by the following centres, pro-otic, epi-otic, opisthotic, and pterotic, belonging to the periotic capsule; by the ex- and squamo-

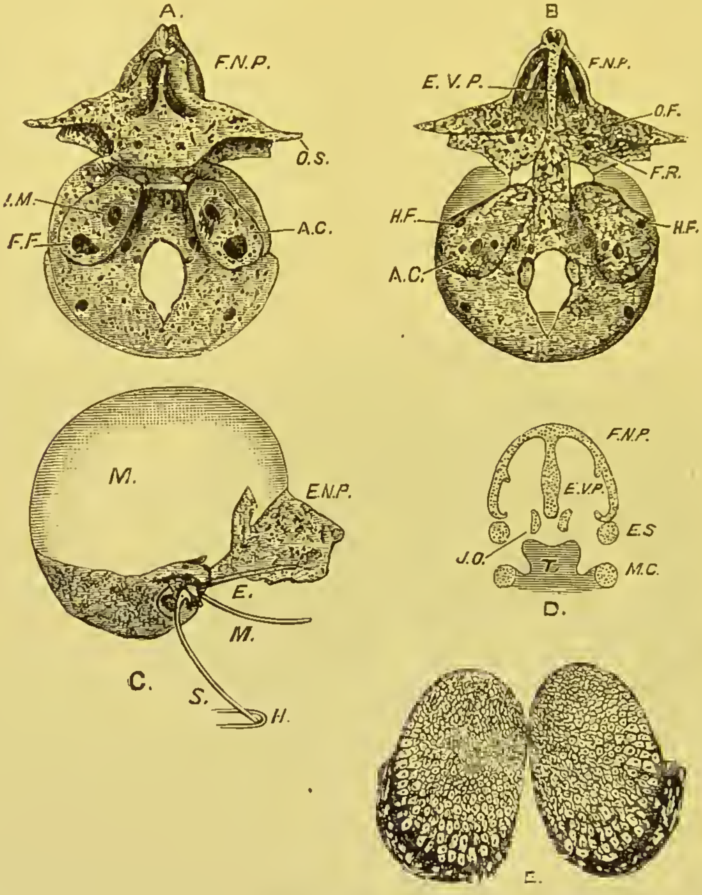

FIG. 123.—FOUR VIEWS OF THE HUMAN SKULL IN ITS CARTILAGINOUS CONDITION.

The remnants of this cartilage may in later life become the starting-point of enchondromata and osteomata. A, the skull viewed from above: F N P, fronto-nasal plate; O S, orbito-sphenoid; A C, auditory capsules. B, the same skull viewed from below. C, side view: F N P, fronto-nasal plate: E, Eustachian cartilage; M, Meckel's cartilage; S, styloid cartilage. D, section through the facial region of the same skull. E, a section through the tip of Meckel's cartilage preparing for ossification.

occipitals, and by the stylo- and tympano-hyal ossifications. Thus no less than eight independent ossific centres invade this cartilage, and come into more or less close relationship near the region asterion. In this scramble little tracts of cartilage get locked in, and may often be seen in young skulls, from the fœtus up to puberty. Of all regions of the skull, this is by far the most frequent seat of exostoses; this is true, not only of man, but of some animals, particularly horses.

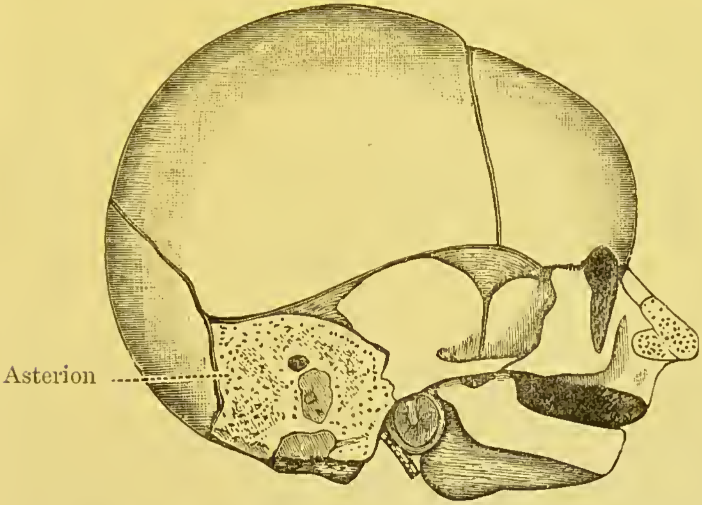

FIG. 124.—SKULL OF A FŒTUS AT THE FIFTH MONTH.
Showing the chondral condition of the region asterion.

In a short but interesting paper, Professor Turner* drew attention to some observations of Seligman, Welcker, Barnard Davis, and adds some of his own, calling attention to the fact that in certain deformed skulls described as Titicaca's, Huanaka's, and Aymara's, exostoses in the neighbourhood of the external auditory meatus existed. Also in skulls from the natives of the Marquesas Islands, and in deformed Peruvian skulls, these growths have been detected. More recently, Professor Turner has described similar exostoses in Sandwich Island, Chatham Island, and New Zealand crania.† He is careful to point out that these exostoses are not race-peculiarities, as Professor Welcker was also aware, and this is borne out by the fact that in the Barnard Davis collection exostoses occurred in races widely separated. The late Mr. Toynbee stated that out of 1013 ears he dissected, fourteen cases of bony outgrowths from the walls of the meatus were found. These facts seem to strongly support the view that exostoses in this region arise from the islands of cartilage so common in this situation.

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* "Journal of Anat. and Physiol.," vol. xiii., p. 200.

† Report on Crania collected by H.M.S. *Challenger*, "Zool. *Chall.* Exp.," pt. xxix., 1884.

If it be admitted that exostoses in relation with the external auditory meatus arise in this way, the same applies to osseous tumours in relation with the jaws, orbits, nasal fossæ, pelvis, vertebral column, and long bones of the limbs. The fossæ of the skull were originally fashioned in cartilage, and untransformed tracts of this tissue may occasionally be detected, especially in young skulls.

In the case of the nasal fossæ, the matter stands thus:—If the skull of the fœtus be so dissected at the fifth month that all the facial bones be removed without injury to the underlying soft tissues, the axis of the face will be found modelled in hyaline cartilage, presenting itself as shown in Fig. 123 A, or in transverse section, as in D.

If a similar section of the face be made at birth, it will be found that large portions of this cartilage have been absorbed, due to the pressure of the overlying bone. In this way the penthouse-shaped piece of cartilage is broken up into outlying islands, some of which are directly ossified to form the turbinate bones, others persist for a longer or shorter period; whilst in rare instances one or more develop with the face and form veritable neoplasms (enchondromata), which may eventually ossify (osteomata).

Sub-ungual exostoses afford evidence of the existence of tumour-germs. If we examine a first or second phalanx of the hand or foot during development, it will be easily seen that ossification commences in the centre of the shaft and spreads towards either end, exactly as in cases of other long bones; eventually the base is finished by an epiphysis. In the case of the terminal phalanges, Dixey* has shown that ossification begins at the tip, and not the centre of the phalanx, and spreads upwards. A careful examination of fœtal fingers served to convince me that in the terminal phalanges little nodules of untransformed cartilage often exist; this offers a possible explanation of those small subungual exostoses described by Dupuytren. Although most frequently seen on the terminal phalanges of the toes, nevertheless they occur on the corresponding phalanges of the fingers.

Osteomata are frequently found in connection with the vertebræ, and it is easy to show that the mode of ossification of these elements of the skeleton is favourable to the formation of cartilage islands. In its simplest state a vertebra is modelled in pure cartilage. Later the body ossifies, and centres appear for the laminæ and pedicles. The bodies are in part ossified from their intrinsic centres, and in part from the pedicles; a line of cartilage long occupies the neurocentral suture. At puberty, the epiphysial plates, the transverse and in the lumbar region the mammillary processes begin to ossify; at this period there are no less than eight lines of cartilage undergoing active transformation. If perturbation occur, "islands" may be formed, constituting potential neoplasms.

Among other examples of tumour-germs must be mentioned the observation of Doran,† who found in the paroophoron of a seven-months human fœtus two incipient papillary cysts. These cysts originated in the remains of the mesonephros, which may be found in this situation in the human subject. Not only are they interesting because of their origin in the remains of fœtal organs, but in the curious circumstance described on page 156, that occasionally their contents are diffused into the peritoneum, and in some few instances general infection of the membrane has been the result.

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* "Proc. Roy. Soc.," vol. xxx.

† "Path. Soc. Trans.," vol. xxxii., p. 147.

For observations in support of Doran's statement, the reader is referred to the section dealing with cystomata in connection with the ovary, on page 205.

The development of some kinds of neoplasm in connection with the jaws—odontomata, dentigerous, and possibly other forms of cystic growths—may be positively ascribed to pre-existing teeth-germs which never advanced to maturity. In the case of dentigerous cysts we have a very clear example: a tooth fails to develop, and the interior of the follicle becomes distended and forms a large sac.

When dealing with odontomata, examples were adduced with the view of demonstrating that under certain conditions the follicular walls may thicken, and subsequently calcify, constituting cementomata.

Nævi may be regarded as tumour-germs; more than one instance is on record where a nævus, not treated in early life, later developed into an angiomata, or its tissue degenerated and formed a sarcoma. For an example of nævus which in later life became an aneurism by anastomosis, see a case reported in "Path. Soc. Trans.," vol. xxxi., p. 88, by Mr. F. Eve. Just as all nævi do not develop into neoplasms, though they exist throughout a long life, neither do all embryonic germs become tumours.

Three very distinct and definite roads are open to these rudiments—(1) they may later in life undergo transformation into normal tissue; (2) they may remain quiescent throughout life, unless (3) irritation stimulate them into abnormal activity. As to what constitutes irritation in this sense nothing at present is definitely known.

Moles, the well-known mother-marks, have long been recognized as potential sources of tumours; numbers of cases are on record where one has remained quiescent throughout a long life, and suddenly, often without any recognizable cause, has become the starting-point of a malignant tumour, carcinoma or sarcoma. This is only another example, of which there are very many recorded, of the known tendency which imperfectly-matured organs or tissues exhibit to become later in life the seat of new growths. The most remarkable of all such strange cases are those instances of malignant growths springing up in dermoid tumours. This is, perhaps, not so much to be wondered at when we take into consideration the large amount of ill-developed tissue these tumours always contain.

Doran* draws attention to this circumstance, and further points out that many of the cartilage knobs and osseous masses, etc., may by analogy be regarded as enchondromata, osteomata, etc., and so forth—in fact, a *tumour of a tumour*,—and certainly there is no objection to the view.

If we admit the existence of cartilage-germs—and to my mind it is indisputable,—the rest of the theory, so far as mesoblastic tumours are concerned, is easy. True exostoses (*vide* p. 257) must be regarded as *ossified* enchondromata. Embryonic connective tissue exists everywhere in the body, continually developing; and as the three tissues — cartilage, bone, and connective tissue—are to be found in every vertebrate that moves, so are sarcomata, fibromata, osteomata, and enchondromata the most widely diffused of all growths; they occur in fish and all intermediate forms up to man. We have reliable evidence of the occurrence of osteomata in extinct forms; indeed, these growths constitute an ancient inheritance. If these varieties arise from tumour-germs we cannot deny a similar mode of origin for other mesoblastic neoplasms.

Again, if neoplasms do not arise from germs or pre-existing tissue, how is it that they are always confined to regions of the body where elements similar to those of which they are composed exist?

Before quitting this question, attention must be directed to the sarcomata. There are now many cases of sarcomata recorded in which the determining cause seems to have been injury. This coincidence has been noticed by several surgeons, and recently Mr. Pearce Gould has collected the evidence and furnished very many references of value in a paper* dealing with the subject.

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* "Tumours of the Ovary."

So far as my observations on animals have extended, they go to show that sarcomata are found with greater frequency in those parts exposed to injury. Thus, in fish the tails and fins are the favourite situations. In frogs they occur on the limbs; in birds, on the neck and more especially on the wings. In horses, I have seen them develop after a blow on the jaw; and in a cat, a sarcoma formed rapidly on the head after an injury from a stick. In one curious instance, an ox broke its horn; a few months later a huge sarcoma developed on the stump.

With regard to round-celled sarcoma, there can be little doubt that very many cases of the diffused variety of these growths have been described as such when in reality they were inflammatory in their origin, and in numbers of instances were due to parasites, or some form of infection. Indeed, so frequently has this been the case, that I have learnt to look upon all examples of round-celled sarcomata, when more than one has been present in the same patient, with a considerable amount of suspicion.

One other factor in the etiology of neoplasms requires consideration, viz., the influence of heredity. Many excellent observers in pathology hold the view that enchondromata, osteomata, and lipomata are hereditary. Virchow and Paget have reported instances in support of the transmission of enchondromata. Several surgeons have recorded cases in support of the hereditary nature of osteomata, the transmission affecting several generations. Mr. Eve has also collected some evidence on the question.†

The subject is of importance in connection with the light it seems to shed on some singular formations which appear with great constancy in certain animals, and the further discussion of the question will be deferred until we come to consider the part played by pathology in evolution (Chapter xxii.).

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* "Lancet," Dec. 5, 1885.

† "Brit. Med. Journ.," 1886, p. 91.

In the case of the roach affected with sarcoma, figured on p. 283, Professor Charles Stewart kindly informed me that as he was anxious to obtain other examples of the condition, he advised that the pond whence this fish was obtained should be dragged or netted. This was done, and several roach were taken in a similar condition. The circumstances of the case support the view that in this instance the fish either inherited their sarcomata or the tendency to their formation.

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CHAPTER XIX.

NEOPLASMS CONTAINING EPIBLASTIC AND HYPOBLASTIC TISSUES.

Epithelial Neoplasms.

The characteristic feature of the neoplasms now to be considered is, that in addition to tissues mesoblastic in origin, they contain *epithelial elements*. These growths consist of a framework or stroma of vascular connective tissue, in which the epithelial cells are embedded, the variety of the neoplasm depending (1) upon the relation or proportion of the cell-elements to the stroma; (2) the arrangement of the cells in the alveoli; (3) the type of construction, or *mimicry*.

Many resemble, in their structure, glandular organs, and exhibit a very definite likeness to particular glands; they have been termed in consequence adenomata.

If the glandular type be imperfectly followed, so that we distinguish only clusters of epithelial cells in nests formed of fibrous tissue, the term carcinomata is applied to them. The essential difference between an adenoma and a cancer is, that in the former the cells tend to clothe the walls of the alveoli in a regular way, leaving central cavities, like the acini of a gland; whereas in the cancers no such lumen or orderly disposition of the cells can be detected, but they are all tumbled in confusion into the nests formed by the fibrous tissue. It must be borne in mind that sarcomata sometimes mimic this alveolar arrangement. The distinction between an alveolar sarcoma and a carcinoma is, that the cells in the latter are of epithelial origin. It must be admitted, however, that it is exceedingly difficult in some few cases to distinguish between a cancer and an alveolar sarcoma merely by the structural details; hence it is important to be acquainted with its mode of genesis.

The various growths grouped under the term epithelial neoplasms agree in two points—(1) they originate from aberrant epithelial germs; (2) the epithelium furnishing the germs is derived either from the hypoblast or epiblast.

It has been raised as an argument against the embryonic classification of neoplasms, that some of the epithelial growths originate from endothelium derived from the mesoblast. If this be true, the objection is a serious one. The neoplasms which appear to be the stumbling-block are those arising in connection with the reproductive organs. The objection fortunately is more apparent than real, as a critical consideration of the origin of the epithelium of the pleuro-peritoneal (cœlom) cavity will show.

It has been customary to regard the cœlom or pleuro-peritoneal cavity as being directly connected with the vascular system; but the Hertwigs and Balfour have shown that this connection is a secondary and later development. This cavity is not a mere sac, such, for instance, as that of the arachnoid, but is a derivative of the hypoblast, and is lined, not with endothelium, but with a true epithelium.

For a full discussion of the subject the reader should consult Balfour * "On the Origin of the Germinal Layers," and the memoir of O. and R. Hertwig.† Briefly the matter is as follows:—

In most of the vertebrata the cœlom or pleuro-peritoneal cavity arises as a schizocele, the result of the splitting of the mesoblast into somatopleure and splanchnopleure. The origin of the mesoblast is a very intricate question; but there is every reason to regard that portion immediately in relation

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* "Comp. Embryology," chap. xii.

† "Die Cœlomtheorie," Jena, 1881.

with the hypoblast as a derivative of that layer. In lower forms the body cavity or cœlom is originally a part of the primitive alimentary canal or archenteron. The lateral portions are gradually abstricted from the central cavity, which persists as the alimentary canal. Thus it must be evident that the lining epithelium of the diverticula or detached portions which now constitute the pleuro-peritoneal cavity or cœlom must clearly be a part of the hypoblast. Thus the epithelium lining the glands arising in connection with the peritoneum, *e.g.*, the testicles, ovaries, peritoneal funnels, etc., is also to be regarded as of hypoblastic origin.

Not only is it necessary for us to carefully consider the relation of the cœlom and its lining epithelium to the hypoblast in its bearing on the source of the epithelial cells (and therefore of epithelial neoplasms) of the reproductive organs in the male and female, but it also becomes important in regard to certain observations in relation with teratomata connected with the testes and ovaries to be considered in chapters xx. and xxi.

Classification of Epithelial Tumours.

(1) Adenomata.
(2) Carcinomata.
  (*a*) Epitheliomata.
   Squamous.
   Cylindrical.
  (*b*) Medullary.
  (*c*) Scirrhus.
  (*d*) Colloid.
(3) Papillomata.
  (*a*) Epidermal.
  (*b*) Mucous.

(1) *Adenomata.*—Adenoma is the name given to a neoplasm whose histological details conform to the type of a secreting gland. Care is necessary to discriminate between hyperplasia of a gland and a glandular neoplasm, the distinction being this—the latter is impotent to produce the secretion normal to the gland, and is foreign to the tissue in which it is situated, notwithstanding the fact that it originated from pre-existing gland-structures, and often in the substance

of glands. Microscopically adenomata can always be distinguished from the glands they mimic.

These neoplasms may undergo secondary changes, such as fatty degeneration of the epithelium, caseation, and mucoid softening. Dilatation of tho saccules and tubules may occur, leading to the formation of cysts, which may attain considerable dimensions.

Adenomata are as various in their type as the glands which they simulate. In the mamma they mimic the acini of that gland; whilst in the nasal fossa or antrum an adenoma resembles the mucous glands found in these situations. At the pylorus many of the neoplasms exhibit tho type of tubular glands, and in the horse may attain a weight of twenty pounds or even more.

In the rectum many adenomata, clinically often described as carcinomata, resemble in their histological details Lieberkühn's follicles. In the liver glandular tumours simulate the normal liver-tissue; whilst in the skin one variety, known as sebaceous adenoma, mimics the sebaceous glands. These facts show that adenomatous growths may imitate almost any form of secreting gland.

From the more typical varieties we pass by insensible gradations into carcinomata, and the lines of distinction become so faint that competent histologists fail to agree as to whether a given growth shall be classed as an adenoma, a cancer, or a tubular epithelioma. In this way the group of epithelial tumours begins with adenomata at one end, and passes by insensible gradations into carcinomata, with the scirrhous variety at the other.

As a good illustration of the homogeneity of the group of epithelial neoplasms, and the difficulty in some cases of assigning any particular growth to a definite subdivision, Mr. Barker's case of tubular epithelioma of the upper jaw, published in "Pathological Society's Transactions," vol. xxxvi., may be mentioned. When the specimen was originally exhibited it was called a carcinoma, a papilloma, an adenoma, and a multilocular epithelioma, by as many skilled observers!

This case is probably an example of the variety of growth termed multilocular epithelioma by Mr. Eve, and probably originated from aberrant growths of epithelium derived from suppressed enamel-germs.

For exquisite drawings illustrating the varieties of adenoma consult—Harrison Cripps for rectal adenomata, "Path. Soc. Trans.," vol. xxxii.; F. T. Paul for hepatic adenomata, "Path. Soc. Trans.," vol. xxxvi.; Green, "Pathological Anatomy—Adenomata"; Zeigler, "Pathological Anatomy —Adenomata," vol. i.

(2) *Carcinomata.*—A carcinoma is a growth characterized by epithelial multiplication. Its essential and distinguishing features are as follows:—The cells are grouped together irregularly within alveoli formed of a more or less dense fibroid stroma, but there is no intercellular substance. The varieties of cancer are based mainly upon the form of the cells, the mode of infiltration, and the abundance and texture of the stroma.

As has before been remarked, the cancer differs from an adenoma in the circumstance that the cells, instead of clothing the alveoli regularly, as in the acinus of a gland, are tumbled in the alveoli in great confusion. Carcinomata resemble glands in another very significant way, namely, in their relation to the blood-vessels and lymphatics. In the normal gland, although it is abundantly supplied with blood, the vessels never come directly into contact with the secreting elements, but are entirely confined to the interstitial tissue which binds the various gland-elements together. Lymphatics intervene, hence the gland obtains its nutriment through their mediation. It has long been pointed out that cancers and sarcomata differ in the very important feature that the former are abundantly supplied with lymphatics, but the latter are not; indeed, the secondary deposits of cancer are the result of the diffusion of the malignant elements by the lymphatic system. Here, then, is another fact tending to indicate that cancers are aborted and aberrant glandular tissues. It is also equally significant that primary cancer never occurs in organs normally devoid of gland-tissue, *e.g.*, the brain, spinal cord, nerves, bone, and cartilage.

Epitheliomata.—Of this form there are two varieties, squamous and cylindrical, according to whether the cells of the growth are flat (squamous) or columnar (cylindrical). This will depend mainly upon the situation of the growth.

For example, if an epithelioma affect the lip, it is certain to be of the squamous variety; if, on the other hand, the rectum be the seat of its manifestation, the growth will be of the columnar type.

Epitheliomata are exceedingly prone in human beings to occur at those spots where skin and mucous membrane join, or in those situations in mucous membranes where there is a transition from one variety of epithelium to another, *e.g.*, in the middle of the œsophagus, at the junction of anus and rectum, vagina and os uteri, etc.

Although epitheliomata are of such frequent occurrence in man, nevertheless they seem to be excessively rare in animals, if the cases be rigidly analysed. The following example, which occurred in a Japanese wolf, is of some interest. In this instance the mucous membrane lying between the tongue and the gum had become raised into an elongated, hard, leathery mass, three inches in length, and two at its greatest width. Its surface was perfectly smooth and imparted a sensation as of soft leather to the touch. At the anterior portion a rounded patch of ulceration about the size of a sixpence, with hard raised edges and a granulating base, was found. When examined microscopically the papillæ were found to be absent, and the surface presented a homogeneous appearance, whilst the deeper layers of the submucous stratum were thickly sprinkled with small round cells. The ulcerated area was characteristic of epithelioma. In its general character the abnormal patch was not to be distinguished from the leathery patches occasionally seen in the human subject, and frequently termed ichthyosis linguæ and psoriasis; in both forms—the so-called ichthyotic and leathery patch—epithelioma is prone to supervene. Besides this example in the wolf, one other case only has come under my notice, and that occurred at the anus of a dog. Veterinary literature contains several recorded examples, but the details of the minute structure are so meagre that it is not satisfactory to quote them as genuine cases. Besides, on more than one occasion, penes have been shown me, which were removed from horses said to be affected with epithelioma, but the supposed cancers were simply crops of soft warts.

Medullary Cancers.—Neoplasms presenting alveoli filled with cells epithelial in type, mimicking racemose glands; but the cells fill the alveoli in confusion instead of clothing the walls regularly. Cells are abundant; stroma scanty, but vascular. This variety of carcinoma is frequent in human beings, and is the commonest variety affecting animals.

Encephaloid cancer is often found in the testicles of man. The same holds good for mammals, as the following cases will serve to show:—

The first concerns an aged grey pony, a rig. At its death an immense lobulated tumour occupied the lumbar region, weighing twenty pounds. The left testis was retained in the abdominal cavity. It measured eight inches in length, and was of corresponding breadth and thickness. Its surface was covered with small lobulated growths. On section the testis presented a various-coloured surface, dark towards the centre, where there was some calcareous deposit. The epididymis was much enlarged and diseased like the testicle; the enlargement extended through the cord for a distance of eight inches. The specimen was examined by Professor Axe, who pronounced it to be encephaloid—the large mass in the lumbar region being secondary to the disease in the testicle.

Encephaloid cancer has also been reported in a retained testicle of a dog.*

M. Trasbot † has published an excellent example of this affection which occurred in a horse between thirteen and fourteen years old. The animal was of good conformation, and there was nothing to lead one to suspect that there was a retained testis; it had all the appearance of an emasculated animal, and presented the characteristic scar left after the operation of castration. Contrary to the usual rule with monorchids, it behaved itself when with others of its sex, and was not excited when in the presence of mares. For two years and a half a tumour had been noticed in the scrotum of the right side; this was small at first, but gradually increased, and caused the animal to walk lame, until at last it was unable to work, and was brought under the notice of M. Trasbot. At this time the neoplasm was equal in size to a child's head. It felt nodular, was of uniform density, fairly firm, but yielded to pressure and was elastic. The skin and subcutaneous tissue were movable over the tumour. It was also possible to make out the spermatic cord, which at once enabled the veterinary surgeon to come to the conclusion that he had to deal with a growth in the testis. The morbid mass, which weighed six pounds, was removed in the usual way; the surface was covered with large ramified and tortuous vessels. It occupied the body of the testis, and the epididymis was perfectly recognizable. Sections examined under the microscope revealed trabeculæ of fibrous tissue, enclosing lacunar spaces containing cells of various forms and dimensions. The vessels in the trabeculæ and stroma were very numerous, and gave a rose tint to sections cut when the tumour was fresh. On these grounds Trasbot came to the conclusion that the growth was an encephaloid cancer, and then remarked upon the rarity of this form; but some eminent veterinarians deny that these neoplasms are so rare.

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* "Veterinarian," 4th series, vol. xxv., p. 262.

† "Rec. de Méd. Vétérinaire," 1885.

Ten days after the case was reported the animal died, and enormous secondary deposits were found in the abdomen, pelvis, etc.

It is an interesting circumstance to know that even reptiles are liable to the inroads of cancer.

A python (*Python sebæ*) which had lived in the Zoological Society's garden for fifteen years was found to be ailing, and as it grew worse it was deemed advisable to kill it. On making the post-mortem examination the viscera were found to be the seats of an enormous number of secondary growths. The liver measured three feet in length, and was studded with hard yellowish-white nodules, varying in size from a pea to that of a large walnut. The lung contained twenty similar nodules, of the size of peas. The kidneys had each a mass of new growth at their posterior ends, of the dimensions of a walnut. The ovaries had several deposits of the size of an orange, some being rather smaller.

The nodules in all the organs were of a yellowish-white colour, exceedingly hard to the touch, and many on being cut into exuded a greenish coloured fluid. This was most obvious in the ovarian masses.

In histological details they conformed to medullary cancer, being made up of alveoli containing masses of irregular cells. The alveolar walls are exceedingly thin, and in places difficult to distinguish. None of the growths were vascular, and the larger masses showed cavities, the result of disintegration of the morbid growths.

It was impossible to decide as to the original seat of the growth, but, taking into consideration the size of the ovarian tumours, and the relation of the blood-stream to the other organs, it seemed probable that the ovaries were the starting-place of the mischief.

The specimens are preserved in the museum of the Royal College of Surgeons, and figures of the cancerous nodules are given in the "Journal of Anatomy and Physiology," vol. xix., plate xxxiii.

Among these instances of carcinomata must be included one shown at the Pathological Society, London, February, 1885, by Dr. Goodhart. It was the brain of a baboon (*Anubis*), which had a large ragged-looking tumour over the optic chiasma. The nerves and other parts of the brain appeared to be quite healthy. The base of the skull showed, by the eroded condition of the bone, that the tumour had occupied the pituitary fossa, and spread outwards in the adjacent parts of the middle fossa. It evidently had its origin in the pituitary body. The tumour was composed of large epithelial-looking cells, arranged in an alveolar manner. This arrangment of cells, associated with the fact that the pituitary body arises from epiblast, justified it being regarded as a carcinoma.

The animal lived in the Zoological Gardens, London, and presented head-symptoms some weeks before its death. The specimen is now in the museum of the College of Surgeons.

Scirrhous Cancer.—In this variety the cells are less numerous, the stroma very abundant, the tumour is firm and hard to the touch, creaks when cut with a knife, and on section presents the glistening appearance of a firm fibrous tumour. The only difference histologically between this and the preceding variety is the excessive proportion of fibrous stroma.

A morbid growth, corresponding to the above description, came under my observation in a Phalanger; it grew from the mammary gland.* It may be due to accident, but it is certainly very curious that a growth so fearfully prevalent in the human female should be so rare in the lower animals. It suggests facts for future meditation, and should urge those who have opportunities to investigate the matter.

Colloid Cancer.—This resembles scirrhous cancer in the abundance of its stroma, but, in the place of cells, its alveoli are filled with a gelatinous colloid material. This condition is probably brought about by the colloid degeneration of the cells.

The most striking example of colloid cancer that I have seen in animals occurred in the mammary gland of a bitch, the sections of which were placed at my disposal by Dr. Heneage Gibbes. In this case it is possible to distinguish in the sections portions which correspond exactly to medullary cancer, and in other places every stage of colloid change, from a few drops in the middle of an alveolus, to large tracts of degenerated tissue. At the periphery of the tumour the histological details correspond in every particular with what would easily pass as good examples of scirrhous cancer.

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* "Proc. Zoo. Soc.," 1886.

Rayer, Heusinger, Tanchou, and other writers have recorded cases of cancer in animals; but the extremely broad sense in which they employ the term cancer renders their descriptions absolutely useless when submitted to the criticisms of modern pathology.

(3) *Papillomata.*—These growths in their ultimate structure resemble an agglomeration of ordinary papillæ, and, like them, spring from cutaneous and mucous surfaces. In structural details they resemble exaggerated papillæ of the skin, and consist of a base of richly cellular connective tissue supporting blood-vessels, the whole being overlaid by a covering of epithelium, the character of the cells varying with the situation of the growth. Those arising from skin have a hard epithelial investment, whilst those from mucous surfaces are softer in consistence. The individual papillæ may be single, but often possess secondary or tertiary processes.

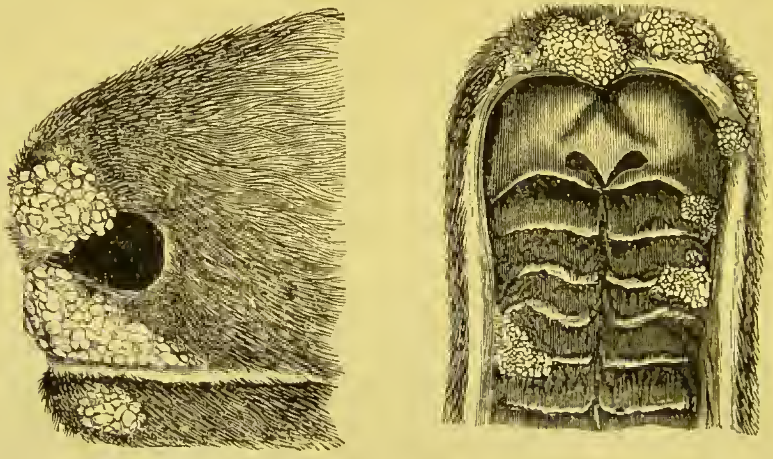

FIG. 125.—THE NOSE OF A SHEEP.

FIG. 126.—THE HARD PALATE OF THE SAME ANIMAL.

Showing papillomata induced by the irritation of stubble.

Some typical examples of warts growing from the side of the nose and hard palate of a sheep are represented in Figs. 125 and 126. Another specimen with them on the tongue is shown in Fig. 128. Whether arising on mucous membrane or skin, they are nearly always the result of irritation, but in certain congenital cases it is difficult to explain their origin. Papillomata later in life exhibit a very remarkable tendency to become epitheliomata.

Warts are occasionally found growing from the œsophagus of the ox, and in such numbers as to give a villous appearance like that normally existing on the mucous surface of the œsophagus of a turtle. Typical specimens are preserved in the museums of the Royal College of Surgeons, and of the Royal Veterinary College, London.

Among other singular situations where these growths may develop should be mentioned the inner wall of sebaceous cysts, and in the interesting variety of papillary cyst found in the hilum of the ovary, and in some rare instances by the side of the uterus.

THE ETIOLOGY OF EPITHELIAL NEOPLASMS.

The epithelial or glandular type of neoplasms presents some important features of morbid development, the type of this class of new-formation being glandular tissue which never attains a functional condition. If the developmental history of a gland be traced, it will be found to commence by a down-growth of epithelium, from the epiblast or hypoblast, as the case may be, into the deeper layers of the mesoblastic tissues. This stage is well shown in the accompanying figure, which represents a magnified view of

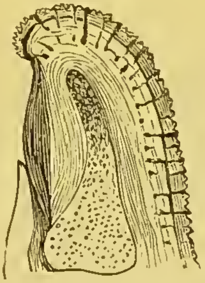

FIG. 127.—SECTION THROUGH THE DISTAL END OF THE THUMB OF A FOURTH-MONTH FŒTUS.

Showing developing sweat-glands.

a section carried through the thumb of a fœtus at the fourth month (Fig. 127). The epithelial down-growth and the mesoblastic elements disport themselves in various ways, and glandular organs of different types are built up, producing mucus, sweat, milk, sebum, or other secretions. If, later in life, irritation, local or otherwise, affects the tissue, abnormal epithelial growths may occur, which, rising above the general level, produce a wart, or, dipping into the subepithelial tissues as in the early stage of gland-formation, but failing sufficient formative energy, either from decline of vigour or general constitutional debility, the new tissue never develops functionally, runs riot, and originates tissues of low vitality—carcinomata. Such ingrowths may occur from any gland—mucous, sebaceous, mammary, and others—as diverticula; and according to the arrangement and variety of the cells and stroma, so we term them epithelioma, scirrhus, encephaloid, and the like.

There is no valid reason why these abnormal down-growths of epithelium as a result of irritation should not be considered as tumour-germs, in the same sense as the little masses of cartilage lodged in the interior of a long bone.

For further arguments as to the relation between gland-tissue and cancer see page 316.

It may be asked, Why should cancer be more frequent in the old or debilitated than in the young and vigorous? The answer is, Young trees bring forth good fruit because in them vigorous growth is at an acme; when this fades, that which is inferior is produced: so with glands. But there is abundant evidence on this head yet to be considered. It is a well-known fact that irritation in the young rarely leads to cancer, but to warts. Children who are uncared for—and even those not neglected are fond of playing with all manner of dirty things—develop papillomata on their hands. In men employed to slaughter cattle infected with pleuro-pneumonia, tuberculosis, parturient fever, and the like, large crops of warts develop on the hands, and distinct exacerbations occur after frequent handling of the offal of these animals. Sheep will afford some good examples. In this country these animals are often turned out to feed on clover, which is frequently grown on fields with the stubble from a previous crop of wheat still remaining. The short, stiff, hard ends of the straws irritate the mouth, nose, and face of the animals, as well as affect the tender parts of the feet immediately about the coronet. As a result of this irritation warts develop, exactly resembling those we see on the hands of children. Their general appearance on the sheep's nose is represented in Fig. 125, and on the tongue in Fig. 128. That these growths are the direct result of the irritation is shown by the fact that when the affected animals are removed from the stubble the warts in nearly every case quickly disappear. Papillomata will also develop on the noses of lambs from grubbing about in the dirt and pools incidental to stock yards.

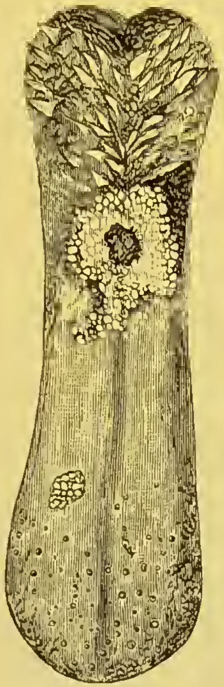

FIG. 128.—THE TONGUE OF A SHEEP WITH WARTS.
Due to the irritation of stubble.

Condylomata around the orifice of the vagina and the anus, due to the irritation of gonorrhœal discharges, are cases in point. The veruca necrogenica is a kind of wart occasionally seen on the hands of dissecting-room attendants, and in one case I saw this affection on the hand of a laundress employed to wash lying-in linen.

Condylomata and veruca necrogenica seem to constitute a connecting form between the usually innocent simple papilloma of the young, and the more malignant epithelioma of those advancing in years. This is especially true of that form known as the soot-wart, which happily is becoming rare in this country.

Dr. Creighton* has pointed out that in many instances wart-like growths found on mucous membranes have relation to a catarrhal process of the surface, where the removal of the products has been interfered with. In the horse, particularly when overworked and ill-cared for, the natural smegma preputii is retained, owing to the fixity of the sheath. The accumulation appears to induce a wart-like condition of the penis.

Papillomata of this kind are exceedingly frequent on the penis of bulls. In this situation they are often termed, erroneously, epitheliomata.

Concerning multilocular cystic tumours of the jaws, Mr. Eve† has recently published some most interesting observations, which support the doctrine of tumour-germs. He points out that these multilocular cysts might with reason be inferred to originate from the enamel rudiment of an aborted or supernumerary tooth. Malassez‡ has also shown that, in the normal condition, spherical, oval, and cylindrical masses of epithelium may be detected within the periodontal membrane, and extend from the gum to the apex of the fang. These masses, he thinks, proceed from some of the epithelial formations accompanying dentition.

There is good reason to believe with Mr. Eve that the multilocular cystic tumours of the jaws are a variety of neoplasm originating from epithelial ingrowths around the dental alveoli. These ingrowths may represent teeth long since suppressed in the process of evolution of our species, or an overgrowth of the normal epithelium of the gum.*

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* "Encyc. Brit.," vol. ix., art. "Pathology."

† "Trans. Odont. Soc. of Great Britain," Dec., 1885, and "Brit. Med. Journ.," 1883.

‡ "Jour. Soc. de la Biologie," 1884, p. 242.

It is now admitted by pathologists that the more atypical a tissue is, the more prone is it to exhibit malignancy. This character is well shown in the group of epithelial neoplasms. Thus, adenomata, which wander least from the glandular type, and which are most frequent in early life, when the formative powers are at a maximum, are among the most innocent of tumours. As life advances, formative energy declines, adenomata grow more atypical and become malignant, *e.g.*, pyloric tumours. In studying the malignancy of neoplasms, and its relation to age, it must be borne in mind that we should judge of age not so much by years as by the condition of the tissues.

Summary.—The main aim of this chapter is to endeavour to substantiate the view that the adenomata and carcinomata constitute a very natural group of neoplasms, formed on the type of a secreting gland. These glands, like dermal organs, project as solid down-growths of epithelium into the underlying mesoblast. In due course a lumen becomes hollowed out in the mass and opens on the free surface of the skin or mucous membrane as the situation of the germ determines, thus furnishing the gland with an excretory duct. The central hollow in which the duct terminates is known as the acinus, or alveolus. A gland thus formed may extend itself indefinitely by secondary offshoots and become compound. The principal secretory organs arise from germs during fœtal life. In a few instances gland-germs may develop after birth as in the case of the uterine mucous membrane.

Abnormalities of gland-development occur at all ages. In the young, the most common form of aberration is an offshoot from a secretory organ which mimics the parent gland ; it is provided with alveoli and typical epithelium, but has not an excretory duct and fails to produce the secretion peculiar to the gland. This is an *adenoma*.

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* For some good figures of multilocular cystic tumours of the jaw, consult Heath, "Injuries and Diseases of the Jaws," 3rd edition, p. 196.

In adult life, abnormal gland-germs fail to advance so far as to form acini, and simply retain their solid primitive condition, surrounded by fibrous tissue. Such are *carcinomata*.

If the cells predominate the cancer is called *medullary* or *encephaloid*. When growth is more deliberate, the fibrous tissue is abundant and cells are at a minimum; the neoplasm is then termed *scirrhus*. Occasionally the cells degenerate, leaving only a gelatinous substance in the loculi. This condition is expressed as *colloid cancer*. The three preceding varieties mimic more particularly such a gland as the mamma. The variety known as *epithelioma* is on the type of sebaceous glands when arising from epiblastic cells of skin, proctodæum or stomodæum, or resemble mucous glands when originating from the hypoblastic epithelium.

In this way the four varieties of cancer—encephaloid, scirrhus, colloid, and epithelioma—like adenomata, are to be regarded as *glandular aberrations*.

CHAPTER XX.

TERATOMATA.

THE teratomata are a group of congenital tumours remarkable for the variety of the elements composing them. They may contain fibrous tissue, bone, cartilage, muscle, skin, hair, nerves, glands, or indeed any tissue. Their most frequent situations are the head, the sacral region, the neck, and the genital organs, ovary, and testis.

When dealing with the subject of classification of neoplasms it was pointed out that this variety contains invariably formed-tissues derived from the three germinal layers, epiblast, hypoblast, and mesoblast. In the course of this chapter occasion will be taken to show that in all the places where teratomata are most commonly found, the regions in question are those where the three blastodermic layers are brought directly into continuity with each other, but the connection is only temporary. More critically examined, we shall find that these temporary unions are often represented by a passage, which may exist for a longer or shorter period in the embryo. As a matter of fact, we get what I have been in the habit of terming a series of obsolete canals; meaning by this, canals which in the ancestors of mammals were functional, but which re-appear in existing forms in obedience to the great law HEREDITY so ably enunciated by Darwin. As examples we may take, (1) the curious passage which brings the infundibulum of the primary encephalic vesicle into relation with buccal involution of the epiblast; (2) the remarkable neurenteric passage which establishes a continuity of tissue between the central canal of the spinal cord and the alimentary canal; (3) the branchial clefts which bring the foregut and outer epiblast into close relation in embryonic life; (4) the curious history of the testes, ovary, and Wolffian ducts; (5) the canal running from the foramen cæcum to the basi-hyoid, named by His the ductus lingualis. Each of these divisions must of necessity be separately considered, for which purpose it will be imperative to enter somewhat into the details of the embryology of the various regions concerned.

Teratomata in connection with the caudal end of the notochord will form a convenient group to commence with, for the evidence which will be advanced in support of the view here advocated is, in the case of these remarkable tumours, of the clearest possible character in this situation.

Sacral Teratomata.—Teratomata occur in connection with the sacrum far more frequently than in other situations, excepting the ovary. In character they vary from a more or less fully formed individual to a shapeless mass of fat, fibrous tissue, cartilage, and the like.

For convenience it will be necessary to divide them into groups:

(1) Parasitic Fœtuses.
(2) Cystic Tumours—Hygromata.
(3) Lipomata.

The first group will not be considered in this place, but attention will be centred on the cystic group and the so-called lipomata.

The most important contribution to this subject is the classical monograph of Braune, entitled "Die Doppelbildungen und angebornen Geschwülste der Kreuzbeingegend," 1862, which contains the details of no less than ninety-five examples of sacral tumours. With regard to the sacral hygromata, Braune distinguishes two chief varieties—one in which the cyst is in connection with the spinal meninges, and is the result of abnormal dilatation of those membranes; whereas the second variety lies anterior to the coccyx, and, according to this observer, arises as a result of the degeneration of Luschka's gland. This last view is shared by other observers, but has little to support it, and arguments will be raised to show that it is untenable.

Braune's typical specimen of the first variety, or that which arises in connection with a diverticulum from the spinal canal, was a preparation in the Meckelian Museum at Halle. The details of the case are diagrammatically represented in Fig. 129, where it will be seen that a cyst with exceedingly thick walls, containing much fat and connective tissue, is in direct communication with the spinal canal through the normal *hiatus sacralis*. The mass was 10 cm. long, 6 cm. broad, and 3 cm. thick. The pedicle with which it was attached to the vertebral column was 1 cm. in breadth.

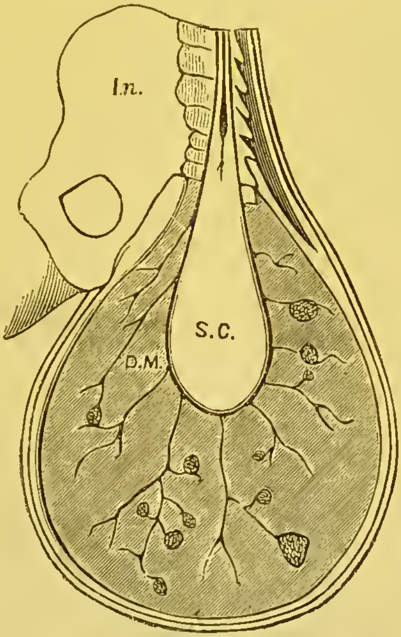

FIG. 129.—A CONGENITAL SACRAL CYSTIC TUMOUR, DUE TO DILATATION OF THE TERMINAL PORTION OF THE SPINAL MENINGES.

S.C., Spinal canal. D.M., Dura mater. In., Innominate bone. (Modified from Braune.)

Virchow, in Bd. 103, Seit 571, of the "Archiv," describes (under the title of "Einen Fall von Hygroma cysticum glutaeale congenitum") an admirable example of sacral congenital tumour which was removed from a newly-born African child in Central Africa by Dr. Ludwig Wolff.

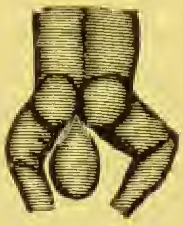

Fig. 130.—Posterior View of a Newly-born African Child with a Sacral Teratoma. (Modified from Virchow.)

When removed, the tumour measured 9·5 cm. in length, and 15·8 cm. in breadth, and was considered to be a lipoma. After preservation in spirit it measured 7·3 cm. by 3·7 cm. The specimen was submitted to Virchow, who found that the tumour had a cystic interior, and that the walls were made up of skin, striated muscle-tissue, fat, connective tissue, and even nerve-fibres. Virchow regarded the tumour, notwith-

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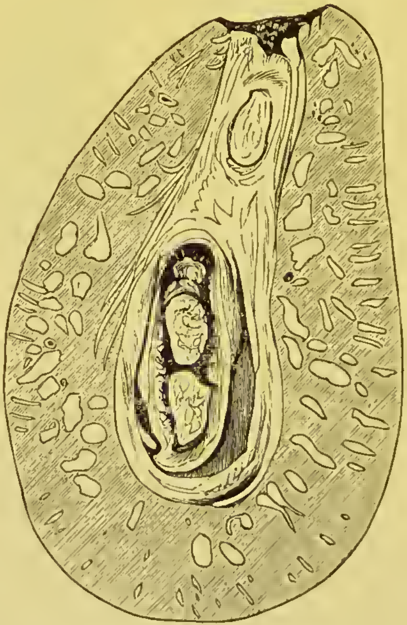

Fig. 131.—A Section of the Teratoma represented in the preceding figure. (After Virchow.)

standing its lateral position, as originating in a diverticulum from the meninges of the spinal cord.

There is no difficulty in accepting this explanation of the nature of the tumour, for on looking at the growth in transverse section (Fig. 131), it is easy to see the similitude between it and Braune's figure, where the connection between the tunics of the cord and the sac of the cyst is actually demonstrated.

As affording useful testimony on this point, the interesting case reported by Mr. Solly in "Med.-Chir. Soc. Trans.," vol. xl., p. 19, may be briefly noticed.

A woman, aged twenty-nine years, consulted Mr. Solly about a tumour of the neck. It was of the size of a goose's egg, hard and unyielding to the touch, and grew from the middle line in the back of the neck near the occiput. The growth was congenital, but had become much smaller since birth. No operation had been attempted, partly because Abernethy, among other surgeons, found it to be connected with the spinal canal. Subsequently, Sir Astley Cooper, Key, and others wished to remove it, but the patient's friends refused interference. Eventually the woman, wishing to marry, submitted to the operation at the hands of Solly, he having satisfied himself that the peduncle of the growth had closed. The examination of the tumour after removal proved its cystic character, and the line of its original commu-

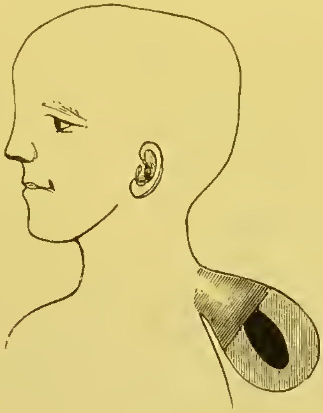

FIG. 132.—DIAGRAM TO ILLUSTRATE THE GENERAL RELATIONS OF SOLLY'S CASE, DESCRIBED IN THE TEXT.

nication with the spinal canal was indicated by yellow elastic tissue.

The account of the structure of the cyst-walls and the general appearance of the growth in longitudinal section show it to be exactly similar to the cases described and figured by Braune and Virchow. The accompanying diagram (Fig. 131) has been constructed from the three figures given by Solly in his original description of this very instructive and somewhat unusual case.

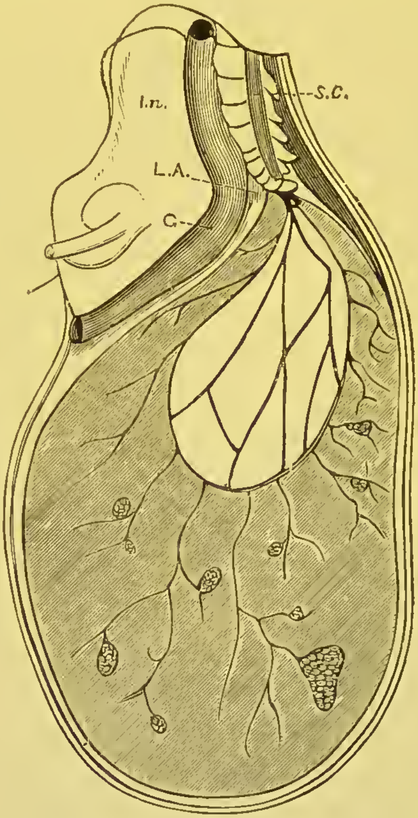

Fig. 133.—Congenital Cystic Sacral Tumour lying anterior to the Coccyx.

S.C., Spinal cord. L.A., Levator ani. G, Gut. In., Innominate bone. (Modified from Braune.)

A critical analysis discloses clearly enough that this variety of Braune's sacral tumours are not teratomata, but an example of spina bifida, and ought to have been described in the section devoted to that malformation (page 189). As the cyst arises as a hernia of the meninges of the cord, it falls under the heading of a simple spinal meningocele. Inasmuch as the essential feature is, that it originates as a diverticulum from a cavity during intra-uterine life, it agrees with the majority of teratomata, which group, as has already been remarked, present one feature in common, viz., a constant relation with tubular structures.

The type of the second variety of Braune are those which he believes have their origin in Luschka's gland (the anatomical relations are diagrammatically shown in Fig. 133). It will be easily seen that the spinal canal is closed, and that the tumour lies anterior to the coccyx and lower end of the sacrum, and that it has between it and the rectum, G, the levator ani muscle, L.A.

The type of this group was also in the Meckelian collection at Halle. It was a seven-months fœtus which had long been preserved in alcohol. Braune designates the tumour as a congenital cystic sarcoma, arising probably in Luschka's gland.

Many examples of this kind are on record—most of them are collected in Braune's book. Since that time, however, Mr. Hutchinson * published a detailed account of a case, and gave references to others. Mr. Shattock † also recorded an example with an admirable description of the microscopic features of the tumour. The cysts and duct-like passages were lined for the most part with cubical epithelium, and held together by richly cellular connective tissue. In many situations the epithelium is columnar, set upon flatter cubical cells. The cysts contained ropy mucus; hyaline cartilage also was found in the tumour. Mr. Wagstaffe ‡ described a fœtus with a sacral tumour agreeing in character with this case.

The view seems to be held by the majority who have studied these singular formations since Braune wrote his work, that these tumours arise in all probability from a degeneration of Luschka's gland; and it has even been suggested that similar cysts occurring in the neck may take their

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* "Illustrations of Clinical Surgery," fasc. xiii.

† "Path. Soc. Trans.," vol. xxxii., p. 197.

‡ "St. Thomas's Hosp. Reports," vol. iv.

origin in the intercarotid gland. This notion, both as regards sacral tumours and those in the neck, must be discarded.

Before proceeding to further discuss the etiology of these teratomata, it will be necessary to take into consideration some recent advances which have been made in embryology, especially in regard to the curious arrangement of canals, etc., which for a brief period exists at the caudal end of the notochord of most, if not all, vertebrata.

The Neurenteric Passage, its History and Relations.—In 1871, Kowalevsky* drew attention to a very remarkable temporary passage which he discovered in connection with the spinal cord.

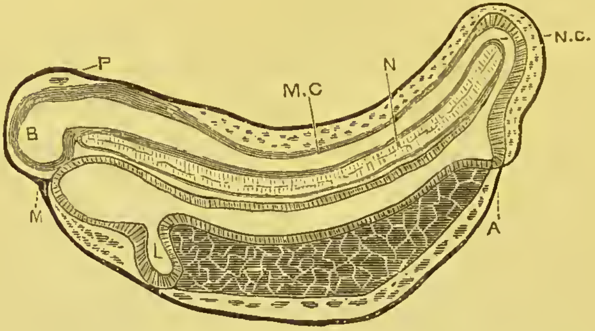

Fig. 134.—A Longitudinal Section of an Embryo of *Bombinator igneus*
B, Brain. P, Pineal gland. M.C, Spinal canal. N, Notochord. M, Mouth.
L, Liver. A, Anus. N.C., Neurenteric canal. (After Gœtte.)

The canal in question, which is now familiar to embryologists as the neurenteric passage, leads from the central canal of the spinal cord, round the posterior or caudal end of the notochord, and opens into a section of the alimentary canal, termed by Balfour the post-anal gut, because it lies posterior to the anus; the communication is, however, only temporary.

Previous to this discovery, the alimentary canal was believed to terminate at the anus, but Kowalevsky showed that in the embryos of Amphioxus, Ascidians, Plagiostomi, and Teleostei it is prolonged for some distance beyond this point into the tail. Later, the anal involution appears, and the gut posteriorly to the anus usually atrophies. The relation of the neurenteric passage to the central canal of the cord and the post-anal gut is shown in Fig. 134, copied from Goette's well-known figure of *Bombinator igneus.*

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* "Archiv. für Mikr. Anatom.," Bd. vii., S. 114.

At first it was thought that this singular arrangement was peculiar to the Ichthyopsida, but later researches go to show that it is an extremely generalized condition. Since attention has been called to the matter, a post-anal gut has been found in animals, from the Amphioxus up to and including man.

The list comprises, besides those already mentioned, Axolotl Bombinator, the fowl, rabbit, and man.

The post-anal section of the alimentary canal, or post-anal gut, has been carefully described by Balfour in Elasmobranchs; in these fish it exists for a considerable period of embryonic life. The gut assumes more or less the character of a stalked vesicle, the walls of which are lined with columnar epithelium; the vesicle communicates with the neural canal by the neurenteric passage.

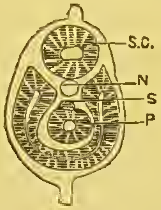

FIG. 135.—TRANSVERSE SECTION OF AN EMBRYO SHARK POSTERIOR TO THE ANUS.

S.C, spinal cord; N, notochord; S, subnotochordal rod; P, post-anal gut.

When at its maximum development, the post-anal gut is equal to a third of the whole length of the alimentary tract.

The post-anal gut, so far as is at present known, reaches its maximum of development in the Elasmobranchs, and gradually diminishes in size as we ascend to the amniotic vertebrata. It is well marked in the higher forms, and in the rabbit extends some distance under the tail.

The developmental history of this part of the alimentary tract has led embryologists to make some speculations regarding the position of the original anus, for they look upon the present one as a modification in animal structure. Interesting, however, as these speculations may be, we cannot follow them here, but must keep to positive facts. However, I would draw attention to one curious point in connection with the atrophy of the post-anal gut, and that is the analogy such atrophy bears to that seen in human subjects when the surgeon renders the rectum and lower part of the colon useless after performing left lumbar colotomy.

The details just discussed clearly show that the post-anal gut, to all intents and purposes, is to be looked upon as a functionless tube, and that the neurenteric passage is to be regarded in no other light than as an obsolete canal; and this designation applies equally to the central canal of the spinal cord. Concerning the significance of the latter we are absolutely in the dark. The important point for my purpose is this—We have here three passages in communication with each other during a certain period of embryonic life, in probably all vertebrata; these later normally become obsolete, but under exceptional circumstances dilate and lead to cystic tumours.

The first to associate a sacral congenital tumour with the post-anal gut was Dr. K. Middeldorpf, in a paper entitled "Zur Kenntniss der angebornen Sacralgeschwülste" ("Virchow's Archives," Bd. 101, S. 37). In this instance a congenital tumour was removed from the neighbourhood of the anus of a little girl one year old. On microscopical examination, the tumour was found to be composed of fat and a richly cellular connective tissue. In addition there was mucous membrane, with characteristic Lieberkühnian follicles, a submucous stratum, longitudinal and circular layers of muscular tissue. A still more striking fact was the existence of a quantity of solitary follicles.

On consulting Professor Wiedersheim concerning the development of this region of the alimentary canal, Middeldorpf was led to the conclusion that the tumour in question may be regarded as a dilatation of the post-anal gut, and in this respect it was no more remarkable than the dilatations which occasionally arise in connection with the omphalo-mesenteric duct, known as Meckel's diverticulum.

That many lymph-follicles should occur in this section of the gut is another feature of interest, for Middeldorpf states that Wiedersheim drew attention to the fact that lymph-follicles are exceedingly abundant in the vicinity of the body-openings, *e.g.*, the glands of the urethra, in men and women; in the mucous membrane of the nose, the bursa Fabricii in the cloacæ of birds. This statement is also true of the tube in connection with the sphenoid, for on the roof of the pharynx we find the so-called pharyngeal tonsil. There is also a collection of lymph-follicles at the spot where the rectum and anus come into continuity.

In all cases of sacral congenital tumour lying anterior to the coccyx which have been reported, and where the details of the microscopical structure can be trusted, the histological details are such as would be expected from the dilatation of a segment of gut lined with cubical or columnar epithelium, and containing crypts and recesses lined with similar epithelium. In several cases in which these cysts have been dissected, gut has been found in them, agreeing in every respect with normally developed intestines. On these grounds, sacral congenital tumours should be removed from teratomata, and classed with the cystomata.

CHAPTER XXI.

TERATOMATA (*continued*).

TURNING our attention from the caudal to the cephalic end of the notochord, we notice a somewhat similar arrangement of parts. It is well known that during early embryonic life that portion of the floor of the skull which supports the mid-brain is represented by two open cartilaginous arms or trabeculæ, which eventually coalesce to form the pituitary fossa.

Although the trabeculæ at an early period form a floor to the pituitary fossa, yet this fossa is never completely shut off from the pharynx in the chondro-cranium; a small opening persists for a very long time, the consideration of which leads to some interesting conclusions, which renders necessary the study of the early stages of the formation of the mouth and pharynx. It has been satisfactorily proved that the buccal mucous membrane is derived from the epiblast; the process by which this derivation occurs is usually described as a tucking-in of that layer, but in reality it is a necessary outcome of the primary cranial flexure. Passing between the open arms of the trabeculæ is a narrow tubular portion of the anterior primary encephalic vesicle, known as the infundibulum; this diverticulum from the primitive brain comes into contact with the buccal epiblast, the meeting-point of the two structures is represented by the pituitary body. This disposition of the parts has long been known.

Whilst engaged working over the development of this complex region, I found that even at the mid-period of intra-uterine life of the human embryo a narrow cavity may be detected passing from the pharynx through the basisphenoid, so as to come into close relation with the infundibulum.

The point of communication with the pharynx is, in the middle line, in contact with the basisphenoid, the spot being indicated at birth by a recess in the mucous membrane, known as the bursa pharyngea. Afterwards, the canal suffers obliteration; but a band of fibrous tissue, passing from the pituitary body to the pharynx, represents the original position of the canal. When the bone is macerated, the fibrous tissue disappears, leaving a hole in the basisphenoid, termed by Landzert the canalis cranio-pharyngeus (" Petersburger Med. Zeitschrift," Bd. xiv.). This cranio-pharyngeal canal may be detected in the floor of the sella Turcica in very many mammals at birth.

Up to the present time I have been unable to assure myself that the lower end of the infundibulum ever opens into the pharynx; but there is every probability that such is the case. However, the existence of this diverticulum of the first encephalic vesicle raises an exceedingly important question, for it seems to me to play the same part with regard to the pharynx that the neurenteric canal does to the posterior end of the alimentary tract, viz., to bring the canal of the central nervous system and intestinal tract into relation, as well as serving for a meeting-place of the two primary layers of the embryo, hypoblast and epiblast, and brings them into intimate union with the third, or mesoblast, filling up the intermediate space.

Exactly as the sacral region is a favourite situation for teratomata, so are the parts in the immediate neighbourhood of this canal. The tumours project into the cranial cavity or into the orbit, hang down into the pharynx, or project through the mouth.

Several examples of these growths have been placed on record. Unaware of any attempt to collect the recorded cases of teratoid tumours found at the anterior end of the notochord, it may be useful to give a brief summary of some of the more important cases.

THOSE IN RELATION WITH THE PITUITARY FOSSA.

BOWLBY, ANTHONY.—A tumour of the pituitary body, composed of vascular connective tissue, epithelial cells, cysts lined with epithelium, and bone. It was of the size of a walnut. Removed post-mortem from a man, aged twenty-two. ("Path. Soc. Trans.," vol. xxxvi., p. 35.)

HALE WHITE.—Tumour of the size of a nut, growing from the pituitary body, and involving the optic commissure. It contained striped muscle-fibre, white nerve-fibres (some in bundles as large as a radial nerve), ganglionic cells, connective tissue, vessels, and fat cells. From a boy, aged twelve years. ("Path. Soc. Trans.," vol. xxxvi., p. 37.)

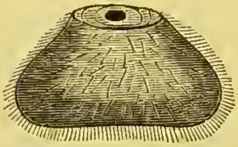

FIG. 136.—PILOSE GROWTH FROM THE PHARYNX OF A GIRL.

LAWSON, GEORGE. — A tumour containing hyaline cartilage, spindle cells, cysts lined by pavement-epithelium and glandular tissue found growing from the body of the sphenoid bone. The growth is described as being large, and filling up the right orbit. Removed from a child, two days old, with a fatal result. ("Path. Soc. Trans.," vol. xxxv., p. 379.)

TERATOID TUMOURS OF THE PHARYNX.

These vary considerably in their character, from a huge tumour containing every variety of tissue normally found in the animal body, to a simple mass of tissue hanging by a pedicle to the roof of the pharynx, and consisting of skin covered with hairs. Of the simple variety the following references may be consulted:—

WARDROP writes, "I remember to have seen the description of a very curious case where a tumour covered with hair appeared in the pharynx." ("Diseases of the Eye.")

ABRAHAM.—A tumour covered with pilose skin removed from the pharynx of a woman, aged twenty-two. On section it was found to contain a nodule of cartilage. It grew from the basilar suture (Fig. 136). ("Journal of Anatomy and Physiology," vol. xv., p. 244.)

HALE WHITE.—A skin-covered tumour removed from the pharynx of a child, aged three years. The growth contained cartilage, connective tissue, skin with hairs, sebaceous and sweat glands. ("Path. Soc. Trans.," vol. xxxii., p. 201.)

It may also be mentioned that as we found two varieties of sacral cysts, viz., those connected with the spinal canal, and others with the post-anal gut, so in the sella Turcica we meet with similar conditions. Thus, in some instances, as detailed in chapter xii., the spinal meninges may bulge through the floor of the pituitary fossa into the pharynx, or we get an abnormal dilatation, simple or complicated, of Rathke's pouch.

Among unusual situations for teratoid tumours must be mentioned the middle line of the abdominal wall in the neighbourhood of the umbilicus. Their occurrence here is very interesting, because it is an old meeting-place of the three primary layers, and the obsolete canal is the remains of the allantois, viz., the urachus.

For details of a tumour in this situation reference should be made to a case read by Mr. J. H. Morgan before the Medical Society, London, 1885.

Teratomata in connection with the branchial arches are not very common; nevertheless, they occasionally occur. The general relations and configurations of these clefts are too well known to need any description, and, as everyone is aware, they are the representatives in Sauropsida and Mammalia of the gill arches in Ichthyopsida, the tympanum being, as a matter of fact, one of the spaces modified to serve as an auxiliary to the function of audition. Among horses and cows it has been on many occasions noted that teeth have grown in connection with the external meatus, and the Veterinary Museum at Alfort possesses an example of a tooth growing from the petrous bone of a cow. When we remember that the upper pharyngeal bones of the fish support teeth, and that the branchial bars support curious epidermal derivatives known as gill-rakers, the growth of teeth in connection with branchial clefts ceases to astound us. In the branchial fistulæ occasionally present, we find permanent evidence of the previous existence in the human subject of the clefts in question, as well as affording an intelligent explanation of the occasional occurrence of sebaceous cysts deeply in the tissues of the neck.

Some interesting cases of cervical teratomata are recorded by Gurlt in his small work on "Cystengeschwülste des Halses," 1855, and others are described in the usual works dealing with malformations of this character.

As in the sacral and pituitary varieties of these growths, we meet with two kinds, simple cystic, and complex examples containing every variety of tissue.

TERATOMATA OF THE OVARIES AND TESTES.

Teratomata of the ovary and testicle remain for consideration. Of all situations in the body, the generative gland in both sexes is by far the most frequent situation in which these tumours are found.

The details of the embryological history of the reproductive organs are exceedingly complex, but the points to which particular attention must be invited are those which will serve to show that we have in their case also to deal with elements of the three primary blastodermic layers and obsolete canals.

The first element to appear is the Wolffian duct, which is seen in the chick about the second day, as a small group of cells lying immediately under the epiblast, in relation with the mesoblastic somites from the seventh to the eleventh. It is usually described as arising from the intermediate cell-mass of the mesoblast; but its close relation to the epiblast renders a positive assertion on this head somewhat hazardous.

Eventually the duct grows backwards as a column of cells lying between the epiblast and mesoblast, and on the fourth day it will be found opening into the cloacal section of the hind gut. Coincident with these changes the Wolffian bodies have arisen in the *intermediate cell-mass*, a collection of cells lying near the spot where the mesoblastic somites diverge into somatopleure and splanchnopleure. The tubules of the mesonephros are developed in this cell-mass independently of the Wolffian duct. In the early stages of the development of these tubules, they are so related to the body-cavity that they may be regarded as rudimentary peritoneal funnels; subsequently these funnels become invaginated by a vascular glomerulus, but the anterior of these tubules and their glomeruli abort very early.

The posterior tubules elongate and open into the Wolffian duct. A fully-formed mesonophritic tubule consists of the following parts:—(1) A peritoneal funnel; (2) a coiled tubule; (3) a wider portion opening into the Wolffian duct. We saw that during the second day the Wolffian duct was lying immediately under the epiblast; on the third day, however, it appears to descend through the intermediate cell-mass, and occupying a lower position, now projects towards the pleuro-peritoneal cavity. Later on, about the fourth day, the Müllerian duct appears, arising in part from involutions of the peritoneal epithelium, and in part by a splitting off from the Wolffian duct. Subsequently we have developed from the intermediate cell-mass, a ridge known as the generative eminence, covered by germinal epithelium, which is continuous with that lining the body cavity.

From this genital ridge the ovary in the female, and the testis in the male, are derived. At the same time the kidney has been developing, its ureter first appearing as a diverticulum from the Wolffian duct, extending into the mesoblastic tissue, which lies chiefly behind the mesonephros; and eventually the kidney replaces this body, which usually atrophies more or less completely. The Müllerian and Wolffian ducts later undergo metamorphosis. If the Müllerian ducts and ovaries grow, the resulting individual is a female; the remainder undergo atrophy. If the reverse of this occurs, the Wolffian ducts and testis become functional, and a male is the result.

In this brief history the great point is, that during the development of the ovary or testis, and the structures with which they are intimately associated, we have a great number of canals developed which subsequently become obsolete, and these canals are in direct relation with epithelium, hypoblastic in origin, which is in the most potential condition possible. Further, we have the Wolffian duct in very close relation with, if not in part derived from the epiblast, aiding still further in bringing about complex relations with the various blastodermic layers.

LINGUAL TERATOMATA (DERMOID CYSTS).

The best account of lingual dermoid cysts, and one easy of access, is by Mr. Barker,* who not only gives an interesting description of a case which occurred in his practice, but has collected and analysed sixteen other recorded examples, and furnishes the following rules concerning them:—

(1) They may be unilateral, lying between the genio-hyoglossi and the mylo-hyoid muscles, on one side or the other. (2) They may be central, lying between the genio-hyo-glossi muscles. (3) They may be bilateral, lying between the mylohyoid and genio-hyo-glossi muscles.

Histologically they consist of tough fibrous walls, with a thin, smooth lining membrane. They contain sebaceous matter and embedded hairs, and perhaps teeth. Mr. Butlin† says of these cysts:—Cases in which their actual existence has been noticed soon after birth have been very few, and the very large majority of dermoid cysts of the mouth have been observed in adults at or upwards of thirty years of age. One case has been described in which the patient was more than sixty years old.

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* "Trans. Clin. Soc.," vol. xvi., p. 215.

† "Diseases of the Tongue."

Professor Wilhelm His, in his recent work,* gives an account of a narrow duct lined with epithelium which runs from the foramen cæcum on the dorsum of the tongue, downwards and backwards between the genio-hyo-glossi muscles, to end blindly in the hollow of the hyoid bone. This is termed by His the lingual canal. Associated and often in connection with the duct is a third or middle lobe to the thyroid gland. This too is in connection with a duct known as the thyroid canal. In embryonic life the two ducts are continuous, and constitute a canal known as the ductus thyreo-glossus. The existence of these ducts admits of no doubt whatever. In the tongue of the human fœtus at birth a thin bristle may often be passed from the foramen cæcum to the hollow of the basi-hyoid. In the adult it is best demonstrated by removing the body of the hyoid bone and carefully dissecting the cellular tissue lying between the genio-hyo-glossi: the duct, if present, is easily found. Up to the present I have searched for the lingual duct fourteen times, and found it thrice in a complete form; in other specimens it could only be distinguished in parts of its course; but in the majority of cases no trace of it could be detected, except the foramen cæcum, and in some specimens even this recess was wanting.

As in other examples of teratoid tumours, we have a duct or obsolete passage traversing a large mass of mesoblastic tissue, and bringing the epiblast and hypoblast into relation. The existence of these ducts also explains, as His is careful to point out, the presence of the accessory thyroid glands and cysts described by Kaydi, Zuckerkandl, and others. The accessory glands and cysts occur as frequently as 25 per cent. in all cases examined.†

The conditions concerned in producing teratomata, when analysed, are these:—

(1) An obsolete canal or canals, once of functional importance in lower animal forms.

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* His: "Anat. Mensch. Embryonen," Bd. iii., "Bildung der Schilddrüsenanlage," 1885.

† See particularly Streickeisen: "Beiträge zur Morphologie der Schilddrüse," "Virchow's Archiv," Bd. ciii., S. 131.

(2) The malformation of parts due to the locking in or adventitious mixture of elements derived from the epiblast, hypoblast, and mesoblast.

(3) These adventitious elements and dilated canals play the part of tumour-germs.

With regard to the old theory of inclusion, it may be briefly stated that facts have accumulated in later years to show how incompetent it is to explain the phenomena in question.

The theory that double monsters originate from one ovum has much to support it. For example, double forms are rarely larger, often not so large, as other individuals born at the same time; if they were the product of two eggs, this would probably not be the case. Double monsters with the bodies sufficiently developed are invariably of the same sex. In support of these statements, Clarke records the following case*:—

In the spring of 1879 he had in his aquarium two or three thousand eggs of *Amblystoma punctatum*, whose development he was studying. One day he chanced to find one with the medullary folds nearly completed, but they had not united at their cephalic end, and appeared to be much elevated and rounded at their anterior ends, instead of ordinary vague outlines, that he kept the egg apart and watched it. Each free portion of the medullary fold developed a perfect head, which, at first partly united, gradually became more so, until they were connected throughout their entire length. Posterior to the heads there were no signs of duplicity.

In this case a two-headed monster with a regular symmetrical body was developed from one egg, and the anterior portion of each medullary fold gave rise to a head. It is surprising that the portion of each medullary fold which ordinarily gives rise to a definite half of the head should in this case have developed a perfect head with paired eyes, ears, and branchiæ.

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* Mr. Samuel F. Clarke: "Anniversary Memoirs, Boston Soc. Nat. Hist.," 1880.

SECTION V.

CHAPTER XXII.

PATHOLOGY AND THE PART IT HAS PLAYED IN EVOLUTION.

There is no person, competent to form an opinion on the subject, who would be found bold enough to deny that disease is hereditary. One or other parent may transmit a disease to the offspring, and this may be handed on to several generations. This is well exemplified in the affection known as hæmophilia. Without adducing examples open to dispute, we may mention syphilis and gout; the capability of transmission from parent to offspring is, in these instances, as well established as any fact in pathology.

The inheritance of structural peculiarities is admitted by all who have devoted any close attention to the matter, and is an important element in the doctrine of evolution. The aberrations thus handed down may be malformations or abnormalities. By a malformation we generally understand some deviation from the usual process of development—either an arrest or an excess of growth in a part. Thus a cleft palate in a child is a malformation from arrest, whilst six fingers on one hand is an excess of the normal growth, and may be traced through many generations. If malformations such as those mentioned above, and diseases such as hæmophilia and syphilis, may be inherited, there can be no reasonable argument raised against the belief that structural changes, the result of disease, may be transmitted from the parent to the offspring.

Paget, in his "Surgical Pathology," refers to the frequent hereditary character of sebaceous cysts, of osseous and cartilaginous tumours; in regard to osseous tumours, he gives reference to cases reported by such eminent observers as Stanley, Cæsar Hawkins, and Jonathan Hutchinson.

It will be shown later on that these three classes of morbid formations, viz., sebaceous cysts, enchondromata, and osteomata, are represented in the animal kingdom by some very extraordinary structures.

It has often been remarked by critics, concerning the theory of evolution, that the custom of docking horses' tails has been practised for many years, yet it has not succeeded in producing stump-tailed animals. Nor has the custom of circumcision in the Hebrew race produced any sensible difference in the length of the prepuce at birth as compared with that of other male children not of the same extraction.

The following example may be of some interest in its bearing on this part of the question:—

There can be little doubt that congenital phimosis runs in families, and the following observation shows it to be distinctly inherited. In 1884, Mr. Croft* communicated to the Clinical Society, London, some curious cases of preputial calculi, the details of which were furnished him by Mr. B. Corney, emigration medical officer in Fiji. In the paper it is stated that "nearly all the natives of the Solomon Islands have congenital phimosis: about one and a half per cent. have the orifice no larger than a pin's head. Only a few of the tribes remedy this condition by art. They slit up the prepuce, generally by means of a sharp shell.

"In the New Hebrides the foreskins are not usually so long, though phimosis is exceedingly common.

"In the island of Malakula all the natives, except one tribe, slit up the prepuce. The Fijians, who are a much superior race, all circumcise or slit the prepuce."

It seems to me fair to regard this general phimotic condition as clearly an inherited defect.

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* "Clin. Soc. Trans.," vol. xviii.

Turning to the tail, we shall find some singular evidence furnished by the feathers of *Momotus*. This bird has the habit of picking off the web of the central feathers of its tail until they assume the spatulate appearance shown in Fig. 137. Several writers have doubted this; but any one sceptical on the matter should read Mr. Salvin's paper, "Proc. Zool. Soc.," April, 1873, and all doubt on this score will be removed. The curious circumstance connected with the affair is this: in consequence of the constant stripping of the web, the feathers, when they first appear, are naturally narrower at the places where they are habitually denuded. This is shown in Fig. 138, taken from

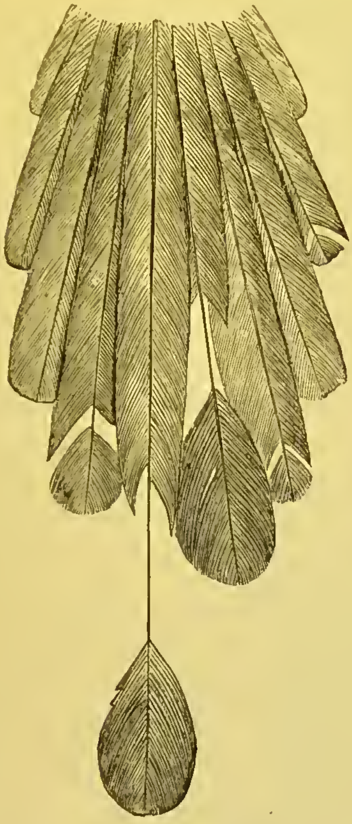

FIG. 137.—TAIL OF *PRIONIRHYNCHUS PLATYRHYNCHUS* WITH CENTRAL RECTRICES ASYMMETRICAL. (After Salvin.)

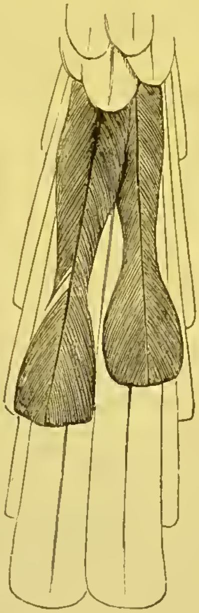

FIG. 138.—TAIL OF *M. MEXICANUS*. The central rectrices, not fully grown, are shaded. (After Salvin.)

a young bird about to commence the nibbling process. The habit is practised by both sexes alike.

These observations are interesting, for it is probable that the spatulate or racket-shaped tails in some other birds may have been brought about in a similar way, so as to become a permanent condition. All degrees may be met with, from a broad web, to others in which the rachis of the tail-feathers is clean from the first.

A further example offers itself in the so-called tailless trout of Islay. A careful and detailed account of this malformation is given by Professor Traquair in the "Journal of Anatomy," vol. vi., p. 411. From this account it appears that the common trout, *Salmo fario*, Linn., is frequently the subject of malformations, of which sigmoid distortions of the vertebral column, and deficient development of the snout and jaws, are the most common. In the present case, however, it is the caudal fin which is affected of all the trout inhabiting a certain small lake. The most salient peculiarity of these Lochnamaorachan trout is that the rays of the caudal fin are abnormally shortened, coarse at the extremities, and deficient as to the amount of dichotomization and number of the transverse joints; besides which, they also show a tendency to coalesce at their terminations. By the convergence downwards of the upper long rays, and upwards of the lower ones, the fin assumes a rounded form instead of presenting the usual broad fan-shaped aspect. The abnormal condition of the extremities of the rays may affect other fins besides the caudal. (Fig. 139.)

The lake in question is about 1,000 feet above the level of the sea. It is about an acre in extent, and so shallow that a man can wade through it: the bottom is of quartz rock. Several other lochs near contain trout, but none are "tailless." So constant is this abnormality in trout taken from the lake in question, that one keen fisher, with thirty years' experience of this loch, has never taken any but docked ones.

It seems to me that these fish clearly inherit their deformity, and that it is a perpetual pathological condition.

It must be distinctly pointed out that the majority of those defects and affections which are usually recognized as being inherited, manifest themselves through a few generations only, and are then lost to observation, and are for the most

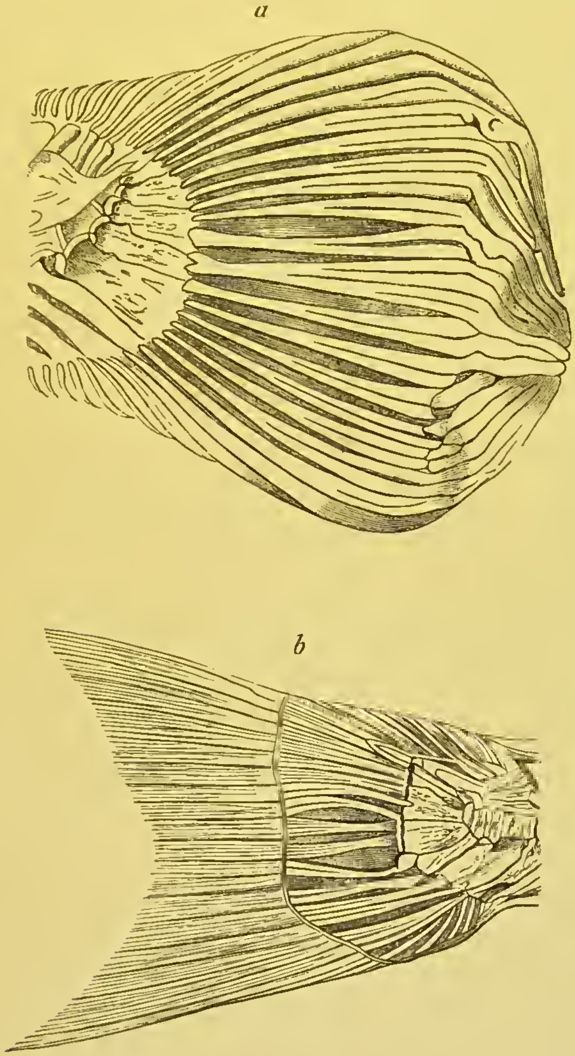

FIG. 139.—THE HARD PARTS OF THE CAUDAL EXTREMITY OF THE TROUT.

The upper figure (*a*) shows the abnormal condition of the extremities of the rays in the so-called tailless trout of Islay (Lochnamaorachan trout). (After Traquair.) The lower figure (*b*) shows the normal condition; it is inserted for comparison.

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part defects of organs easily observed, such as the skin, eye, hair, nails, teeth, and so on.

With regard to skin, ichthyosis is admitted by competent observers to be hereditary; also errors in pigmentation giving rise to albinism. In the case of the eye, such defects as congenital cataract, coloboma iridis, iridremia (partial or complete), and especially abnormal mottlings of the iris, are developmental errors well known to be transmissible.*

Albinism is a defect clearly hereditary, not only in man but in animals. The colourless breeds of rabbits, rats, mice, and snails can be regarded in no other light than as originating in the transmission of a congenital defect. In the case of snails, *Hyalina nitida* has the albino form as an extremely rare aberration, but in *Hyalina cellaria* the albino form is not so rare, whereas in *Hyalina pura* the colourless variety is as common as the coloured; finally, in *Hyalina crystallina*, the albino form is the normal condition, and Mr. Cockerell tells me that he has never yet seen a coloured specimen of this species. These cases might be indefinitely multiplied, but the above are sufficient to illustrate the argument.

Darwin† was fully of opinion that modifications arising in this way may become inherited; but he does not enter in any detail into the matter. He quotes Rengger to the effect that the thin legs and thick arms of the Payaguas Indians are to be attributed to successive generations having passed nearly their whole lives in canoes, with their lower extremities motionless. It is familiar to every one that watchmakers and engravers are liable to be short-sighted, whilst men living much out of doors, and especially savages, are generally long-sighted. Short-sight and long-sight certainly tend to become inherited.

If we admit in only one case that alterations in an organ, the result of pathological changes, can be transmitted to the offspring, then it must have been operative in other instances. The following will serve as a case in point.

When dealing with the diminutive eyes of the mole, in chapter ii., it was pointed out that their rudimentary condition is to be explained on the hypothesis that disuse had been the cause of their atrophy. Darwin, in his "Origin of Species," as well as in the "Voyage of the *Beagle*," draws attention to the eyes of ctenomys, a burrowing rodent even more subterranean in its habits than the mole, and tells us that the Spaniards assured him that it is very often blind. Darwin satisfied himself of the blindness of one of these animals, which he kept alive, and was subsequently satisfied that the blindness was due to inflammation of the nictitating membrane. He then continues:—"As frequent inflammation of the eyes must be injurious to any animal, and as eyes are certainly not necessary to animals having subterranean habits, a reduction in their size, with the adhesion of their eyelids, and growth of fur over them, might in such be an advantage; and if so, natural selection would aid the effects of disuse." Therefore we may regard pathology as having probably played some part in producing blindness in the mole, in addition to simple atrophy from disuse. This view would, of course, only apply to burrowing animals, or those which lived in mud, like the proteus, but would not be applicable to animals who spend their life in the water, like *Amblyopsis*, or in the profundity of the "deep sea," like *Serolis antarcticus*.

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* See particularly Wilde "On the Malformations, etc., of the Eye." Dublin, 1862.

† "The Descent of Man," 2nd ed., p. 32.

It has already been mentioned that several eminent surgeons have recorded observations for the purpose of showing that, in man, osteomata may be inherited. This observation is true of fish, in whom osteomata are fairly frequent.

As far as I can learn, William Bell was the first to describe the very curious exostosed condition of the bones of *Chætodon*. The original description is in the "Phil. Trans.," 1793.

The fish in question is generally about eighteen inches long, thirteen inches broad, and about three in thickness. It is frequently caught at Bencoolen and several other parts on the west coasts of Sumatra.

"The skeleton is very singular, many of the bones having tumours, which, in the first fish Mr. Bell saw, he supposed to be exostoses arising from disease; but, on dissecting a second, found the corresponding bones had exactly similar tumours, and the fishermen informed him they were always found on this fish; he therefore concludes them to be natural to it. (Fig. 140.)

"In Mr. Hunter's collection are two or three of these bones; but Mr. Bell never knew what fish they belonged to; they were supposed to be from the back of some of the large rays.

"In *Chætodon* the tumours are spongy, and so soft as easily to be cut with a knife; they were filled with oil."

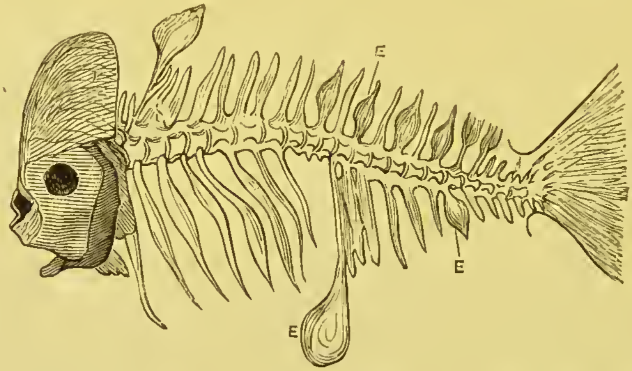

Fig. 140.—Exostoses on Chætodon. (Modified from Bell.)

Rayer, in his "Archives de Méd. Comparée," 1843, refers to Bell's observations, and mentions that the fish is called *Platax noduleux* by Cuvier, but that Schneider, in consequence of the exostoses, called the fish *Chætodon arthriticus* (*arthritique ou goutteux*). Rayer further states that the collection of the Muséum d'Histoire Naturelle contains some specimens of the exostoses, but they were extremely hard. On section, the original limit of the ray could be detected in the thickness of the tumour. M. Valenciennes has also detected numerous exostoses on various parts of the skeleton of *Ephippus gigas*, which, in common with other species of Squamipennes, are liable to these tumours.

In *Ephippus faber* they affect particularly the occipital crest.

For my own part, I do not think, notwithstanding the fact that these exostoses are so frequent, they should be considered in any other light than as pathological in origin, and that the condition has been inherited.

The museum of the College of Surgeons, London, possesses some very excellent specimens of this fish, as well as the original specimen described by William Bell. The most striking feature is the enormous boss of bone which forms on the occipital crest.

Especial stress must be put on this remarkable skeleton. It is incontestable that in this case the osteomata are inherited pathological productions; and further, my own investigations serve to demonstrate that exostoses or osteomata are by far the most generalized (zoologically) of all neoplasms.

As a sequel, an argument will now be raised for the purpose of showing that horns may have originated as pathological productions.

Horns.—In their most characteristic conditions, horns are divided by the Comparative Anatomist into three very distinct groups.

The type of the first group is that found on the rhinoceros, concerning which Sir Everard Home wrote as follows:—"The horn of the rhinoceros is a cuticular appendage, similar to nails and other cuticular excrescences, being in no respect allied to horns but in the external appearance" ("Phil. Trans.," 1791).

The second group are characteristic of deer, and are made up of bone, and arise as outgrowths of the skull.

The third group, characteristic of oxen, antelopes, goats, and sheep, are in part formed by a bony outgrowth from the skull, which becomes invested by a horny sheath developed from the epidermis.

Horns of the Rhinoceros Type.—It happens with extreme frequency in the human subject, that the orifice of a sebaceous gland becomes closed, and as a result of the obstruction the secretion of the gland becomes retained, forming what is known as a sebaceous cyst.

Occasionally the wall of the cyst bursts, and the contents, consisting chiefly of epidermal scales and sebum, project, dry, and become converted into what is known among surgeons as a cutaneous horn. Growth continues at the base of the horn, and it may attain, if not interfered with, a length of many inches. In the human subject they occur on the scalp, cheek, eyelids, nose, leg, and indeed on almost any part of the body (see chapter xi.).

When describing sebaceous cysts, occasion was taken to show that they occur in many animals other than man, and that, as in him, they frequently give rise to cutaneous horns. Some reasons were then adduced to support the opinion that the "castors," or callosities found on the inner side of the legs of horses, may have had their origin in this way, and the defect became transmitted so as to taint the offspring.

If this be admitted, it does not seem too extravagant to suppose that the curious horn characteristic of the rhinoceros may have had its origin as a pathological production, which, being utilized by the animal, was inherited by the offspring, and at last became a race-peculiarity. It is a recognized fact in evolution, that structural peculiarities which are of service to an individual are those most likely to be perpetuated.

Antlers.—These are bony outgrowths from the frontal bones, and differ in every respect from the preceding variety. They are not cuticular productions, but agree in all their essential characters with those morbid bony productions known as exostoses. Like exostoses, they continue to increase in size until their bulk interferes with their nutrition; the antlers then fall. In the same way, an exostosis may suffer necrosis and become exfoliated. Exostoses have a peculiar tendency to develop on the skull and facial bones of all mammals, including man; but of all mammals, exostoses are more frequent among the great group Ungulata than in any other. Indeed, for similar horns we must go to the reptiles, *e.g.*, Owen's chamæleon, whose skull has no fewer than three exostoses.

Among other examples of inherited exostoses must be mentioned the so-called horned men in Africa. As far as I have been able to analyse the evidence, it seems that the Akim men are occasionally seen with huge prominent exostoses growing from their malar bones, giving them a very brutish aspect, such as is shown in the accompanying drawing (Fig. 141).

Judging from the statements which have been made from time to time regarding the existence of these outgrowths from the malar bones, it seems probable that in this particular people they exist as a race-peculiarity. Prominence of the cheek-bone, and osteomata in this situation, are frequently seen in civilized people, and I know of no argument that can be raised against the assumption that in this instance we have to deal with a pathological condition which has become inherited by the males of this particular tribe of Africans.

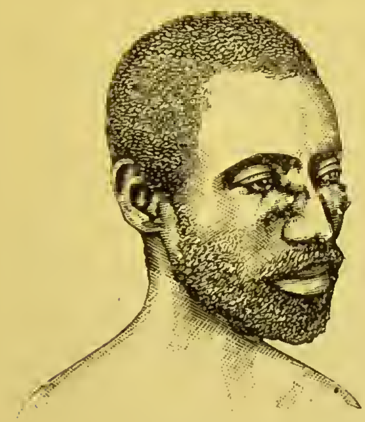

FIG. 141.—HEAD OF SO-CALLED HORNED MAN OF AFRICA. (After Macalister.)

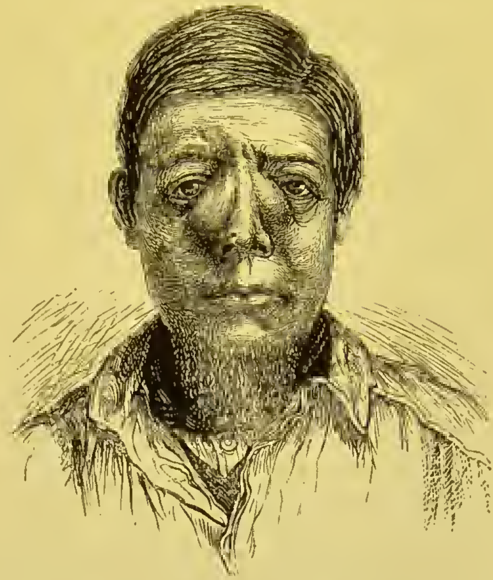

FIG. 142.—SYMMETRICAL EXOSTOSES OF SUPERIOR MAXILLÆ. (After Hutchinson.)

Professor Macalister* further points out, in the paper from which these statements have been gathered, that in this specimen, according to Dr. O'Reilly, the malar participates in the swelling, and that this bone in the Mongolians certainly presents a race-peculiarity in its *tuberositas malaris.*

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* "Proc. Roy. Irish Academy," 2nd ser., vol. iii., 1883: "Further Evidence as to the Existence of Horned Men in Africa."

Leaving the malar bone out of the question entirely, this region is a very favourite one for exostoses, unilateral, central, and bilateral. Thus the man whose head is represented in Fig. 142 had symmetrical exostoses in this situation. His case is reported by Mr. Hutchinson (in the "Illustrations of Clinical Surgery," vol. i., p. 11), who kindly furnished me with the figure. In the same work, a second case is recorded precisely similar, which came under observation; also a unilateral exostosis. I have seen two examples of central exostosis, that is, situated exactly in the middle line of the face. Macalister's and Hutchinson's figures have been placed side by side for comparison.

Hollow Horns.—This third group is to be regarded as symmetrical exostoses growing from the frontal bone, but the pressure exerted on the skin covering them has led to the condensation of the epidermal elements until at last it has become converted into horn. When dealing with the ischial callosities of monkeys, we saw that the callous patches were simply thickened skin, the result of intermittent pressure; in the case of the corneous cap of the horns of bovidæ, we have simply to deal with an exaggerated stage of that process. The same reasonings which have been advanced in support of my view, that antlers are inherited pathological productions, hold good for hollow horns, which are but a modification of that variety.

It may be raised as an objection against my argument, that as horns are utilized for the benefit of the animals possessing them, they cannot be regarded as pathological. Let us closely analyse such an objection. Are the enormous appendages of the wapiti an advantage to that animal? It is questionable. There is good reason to believe that such horns as these helped to exterminate the ancestors of that particular animal. Who can gaze upon the colossal skeletons in the Natural History Museum, and not feel that the enormous tusks of *Elephas ganesa* and the ponderous horns of *Megaceros hibernicus* have played a large part in rendering them less fit to cope with lighter armed and more agile foes? To support such enormous tusks as those of the mammoth, or such weighty horns as megaceros possessed, required corresponding development of skull and bony framework; to meet these demands, agility yielded to solidity, which eventually, like a subtile disease, brought about extinction of the race.

Correlated with the production of these enormous horns is the atrophy, and in many instances total disappearance, of the canine teeth in horned animals; and the gain in one direction has reacted certainly to its disadvantage in this matter.

Who can look at a sloth without pitying the animal, and feeling persuaded that in the possession of those long nails, whereby it hangs suspended from the branches, one reads the history of the failure of its offspring to get a good place in the "race of life," and which will gradually bring about its extinction?

In the chapter devoted to the "Correlation of Organs," occasion was taken to show that whenever one organ underwent hypertrophy, atrophy of some other organ or group of organs was a necessary result. An attempt was also made to attribute to the greater development of one set of the reproductive organs, as compared with the other, the foundation of the division into sexes, so common in the higher forms of life.

Evidence will now be adduced to show that some forms of overgrowth, often confounded with true hypertrophy, have led to some striking racial characters in certain groups of mammals.

In no structure is this principle so admirably illustrated, or so easily studied, as in the teeth of mammals. Take, for example, the curiously modified teeth of the walrus; we shall find the enlarged and formidable incisors have for their companions some tiny functionless teeth of no use whatever to the animal: as a rule they quickly fall; even when they persist, scarcely any sockets are provided for their reception. In this case it can hardly be denied that overgrowth of the canines has led to atrophy of the remaining teeth.

The Felidæ supply us with similar examples. The large size to which the canines attain in this group leads to atrophy of the teeth immediately adjacent to them. This process seems, so far as the Felidæ are concerned, to have reached its culminating point in the extinct Machœrodus, or sabre-toothed tiger, in which the canines have considerable dimensions, whilst some of the premolars in the upper and lower jaws have disappeared.

Let us now consider some other examples of abnormal teeth, somewhat different from the last. The extraórdinary canines of the male babirussa have afforded plenty of scope to those imaginative minds who never come across anything out of the common but they must rack their brains to find out some useful purpose for which they think the abnormal organ may be utilized, never considering for one moment the absurdity of the explanation.

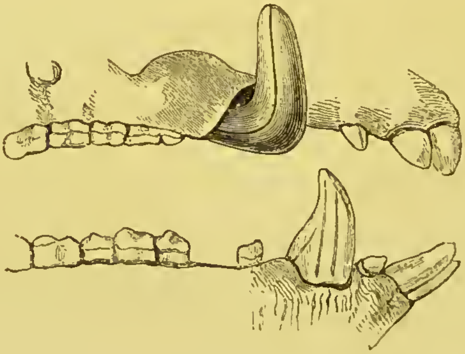

FIG. 143.—THE DENTAL SERIES OF A WILD BOAR.

Showing the singular curve of the upper canine.

As is well known, these teeth, like those of rodents, possess persistent pulps: if from any cause their growth is unopposed, as by want of antagonism between any two teeth, they attain to extraordinary length. In the case of the babirussa it may readily be conceived that, from some cause or other, the upper and lower canines failed to come into apposition, either by malformation or in a manner presently to be explained, and as a consequence grew enormously; the abnormality frequently recurring, the peculiarity became transmitted to the offspring, eventually becoming perpetuated to such a degree as to form a common feature in the anatomy of the males of this particular species.

Considered by itself, this isolated example, perhaps, does not carry much weight, but the condition may be approached insidiously from other specimens of the Suidæ. The first stage may be observed in the wild boar (of which the dentition is represented in Fig. 143), where the form and direction of the canines are peculiar. The lower canine is slender when compared with the upper, is of some length, and plays against the front surface of the upper one, becoming pointed in consequence. The upper canine passes at first horizontally outwards with an inclination forwards. After clearing the outer lip, its apex becomes directed upwards and inwards, describing in its course a semicircle. A similar condition is seen in the wart-hog, *Phacochœrus æliani*; but the second stage is presented by *Phacochœrus æthiopicus*, in which the canine even in the female is very large, as may be seen on reference to Fig. 144.

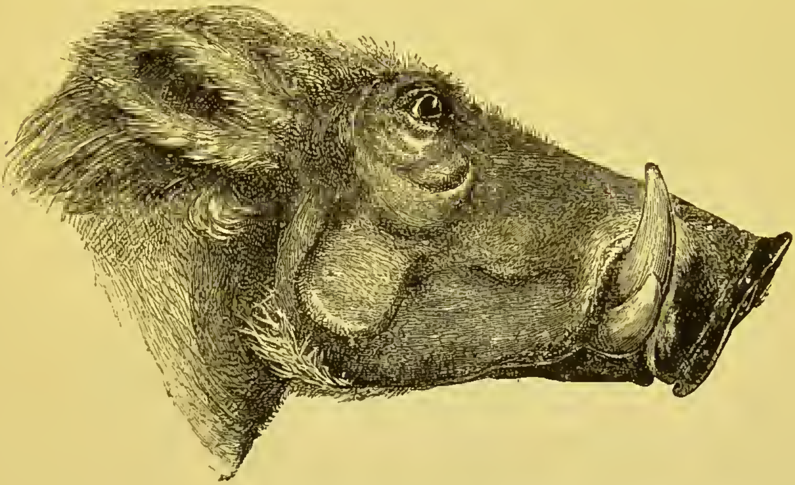

Fig. 144.—Head of Wart-Hog, *Phacochœrus æthiopicus*, ♀

Showing a greater degree of curvature of the upper canine than that presented by the wild boar's tusk.

In the third step we are confronted with babirussa, whose curious canines ought to be regarded as inherited peculiarities resulting originally from want of apposition, probably brought about in the first instance as a result of overgrowth.

This view receives support from the tendency exhibited by the teeth of swine to grow excessively and form circles, as in the babirussa.

Thus in Fig. 146 is represented a canine which had curled in this way, and almost completed the circle. There is in the museum of the College of Surgeons a similar specimen, in addition to the remarkable case described by Cheselden, of which a figure is given on p. 18. There is a well-marked example in the museum of the Odontological Society of Great Britain, where, in the case of a hippopotamus, the tip of the tooth had actually entered the pulp-chamber.

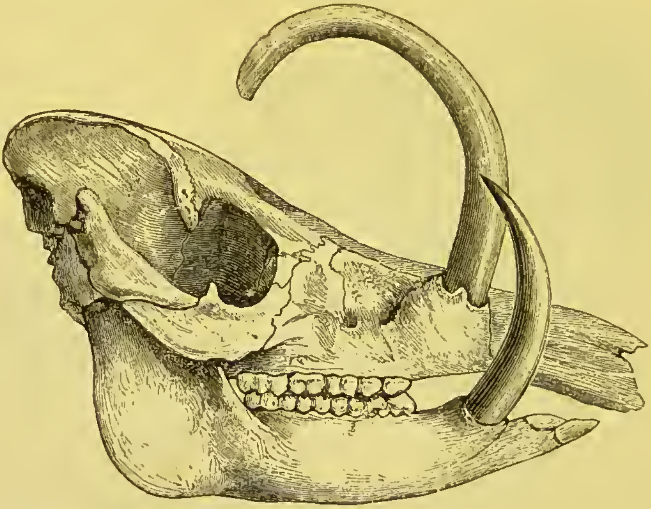

Fig. 145.—Skull of Babirussa.

Showing the most exaggerated stage of curved canines.

Also, in the museum of the Veterinary School at Alfort, I had an opportunity of examining a preparation from a boar, preserved and described by M. Goubaux, in which the course taken by the teeth resembled the condition presented in Cheselden's famous specimen.

There can be little doubt that a similar process has been at work modifying the singularly aberrant tusks of the narwhal, *Monodon monoceros*. Its huge size, the curious spiral twist, undoubtedly correlated with the peculiar unsymmetrical condition of the facial portion of the skull found in this whale, as well as among other members of the Physeteridæ, tend to support the notion of a pathological cause underlying these monstrosities.

In this singular creature, the adult male usually possesses a tooth growing from the left maxillary bone, in close relation with the maxillo-premaxillary suture, and therefore regarded as a canine, which often attains a length of eight, nine, or even ten feet, with a basal diameter of four inches. The corresponding tooth of the opposite side, as a rule, grows up to a certain point, and attains a size of six inches; but the pulp-chamber usually undergoes calcification before it has had time to make its way out of the alveolus, so that it remains concealed throughout the lifetime of the animal. Occasionally, however, this right tusk undergoes development, and equals in size the left one. Mr. J. W. Clark communicated to the Zoological Society, in 1871, the results of an inquiry into the matter of double-tusked narwhals, and has given in that very interesting paper details of no fewer than eleven bidental skulls of this whale in different European museums. This seems to afford evidence that normally the narwhal should possess two teeth, but that from some cause or other the right one often remains suppressed in the alveolus; and there is the significant fact, pointed out by Mr. Clark, that whenever a solitary tooth is present, it is the left one, the right never being developed alone. The spiral twist in connection with these tusks always winds round them from right to left; if two tusks develop, the

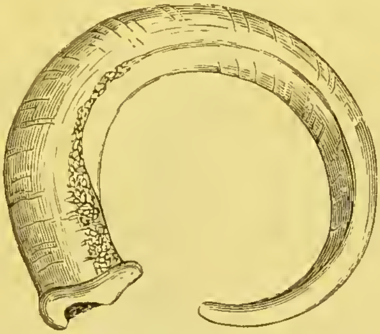

FIG. 146.—CURVED TOOTH OF WILD BOAR.

twist of the spiral is in the same direction in both, as regards the skull right to left, whereas they appear unsymmetrical in respect to one another. There can be little doubt that this curious twist in the tusks is the effect of the same cause, whatever it may be, that produces the remarkable distortion in the facial portion of the skull of these whales. Prof. Flower has described, in the "Trans. Odont. Soc.," 1879-80, some elephants' tusks contained in the museum of the College of Surgeons. These tusks are spirally twisted, the twist possessing, in some instances, two or more turns: a deep groove extends from base to apex. In this instance it is clear that the malformation resulted from injury to the growing pulp when the tooth was in embryo. There is no just reason why the same line of argument should not be applied to the narwhal's tooth. The tusk has yet other interest for the pathologist. Professor Turner was fortunate enough to detect, in the skull of a fœtal narwhal, two rudimentary teeth, all traces of which are lost in the adult, thus clearly showing that this animal originally possessed at least four teeth. After carefully reviewing these facts, the conclusion forces itself upon me,

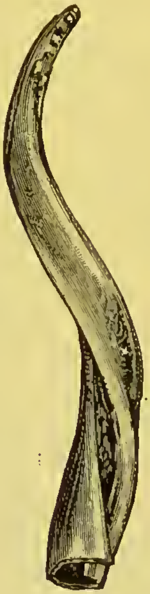

FIG. 147.—SPIRAL TUSK OF ELEPHANT.

that the modified dentition of this most singular animal has been attained by overgrowth of its canine, leading to atrophy of its less used companions; but the original cause of the enlargement is as little known to us as is the cause of the asymmetry of its skull. There is probably no parallel to this in the animal kingdom—extreme overgrowth, excessive atrophy, arrested growth, and malformation, exhibited in the dental armature of a single animal.

Among remarkable teeth must be included those of *Mesoplodon layardi*. The illustration (Fig. 148) represents the anterior part of the rostrum and lower jaw with the teeth of the extraordinary specimen of this whale brought home by the *Challenger* Expedition. The drawing was taken from a model of the specimen in the museum of the Royal College of Surgeons, London. The specimen is thus described by Professor Turner in his "Report on the Bones of the Cetacea":—

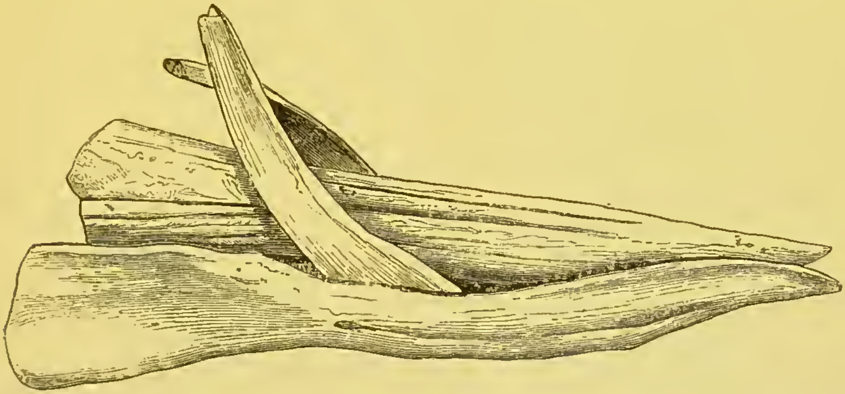

FIG. 148.—THE ROSTRUM OF A WHALE, *MESOPLODON LAYARDI*.
Showing the singularly elongated and curved mandibular teeth. From the specimen obtained during the voyage of H.M.S. *Challenger*. Figure taken from a cast in the museum of the Royal College of Surgeons.

"When I received from Mr. Moseley the lower jaw of the adult *Mesoplodon layardi*, only the left tooth was in its socket; the right had previously been extracted. The socket was situated at the junction of the symphysis with the body of the lower jaw, but more of the tooth was implanted in the body than in the symphysis. The length of the extracted tooth was fourteen inches, six and a half inches of which had been included in the alveolus, or surrounded by the gums. The breadth of the tooth where it emerged from the alveolus was three and a half inches. Each tooth consisted of a denticle proper, and a strap-shaped shaft. The shaft was laterally compressed, and as it emerged from the socket it curved obliquely backwards, upwards, and inwards, so that its inner concave surface had been in relation with the sides and dorsum of the beak. As the summit of each tooth passed to the opposite side of the middle line, the two teeth crossed each other on the dorsum of the beak; and from the smooth appearance of the anterior border and inner surface of each shaft, it is evident that they must have rubbed against each other, or against the beak, during the movements of the lower jaw in the act of opening the mouth."

Besides this specimen, Professor Turner also received the skull and parts of the skeleton of an immature *Mesoplodon layardi*, which enabled him to determine the nature of the various parts of this strange tooth. Each tooth in this immature specimen was two inches from before backwards, and not quite an inch long, and consisted of a small triangular denticle which represented the crown of the tooth, and of a larger part, which for descriptive purposes may be called the fang. The free surface of the denticle was invested with white enamel; subjacent to the enamel there was a well-defined mass of dentine which constituted the mass of the denticle. The exterior of the fang was coated with a thin layer of cementum, beneath which there was a thin layer of substance consisting of a granular matrix traversed by numerous canals, arranged for the most part perpendicularly to the surface of the fang, so as to extend from the dentine to the cementum. The pulp-cavity was lined throughout the greater part of its extent by a well-defined layer of this material. The canals visible in it probably contained blood-vessels; in size they approximated to Haversian canals. This substance in all probability was vaso-dentine.

Turning now to the structural details of an adult specimen of these aberrant teeth, as seen in section (Fig. 149), it will become evident, as Professor Turner has explained, that the peculiar form of tooth is due to changes in the fang, resulting from an enormous overgrowth of cementum and modified vaso-dentine, the former being produced from the alveolo-dentar periosteum, the latter from the pulp.

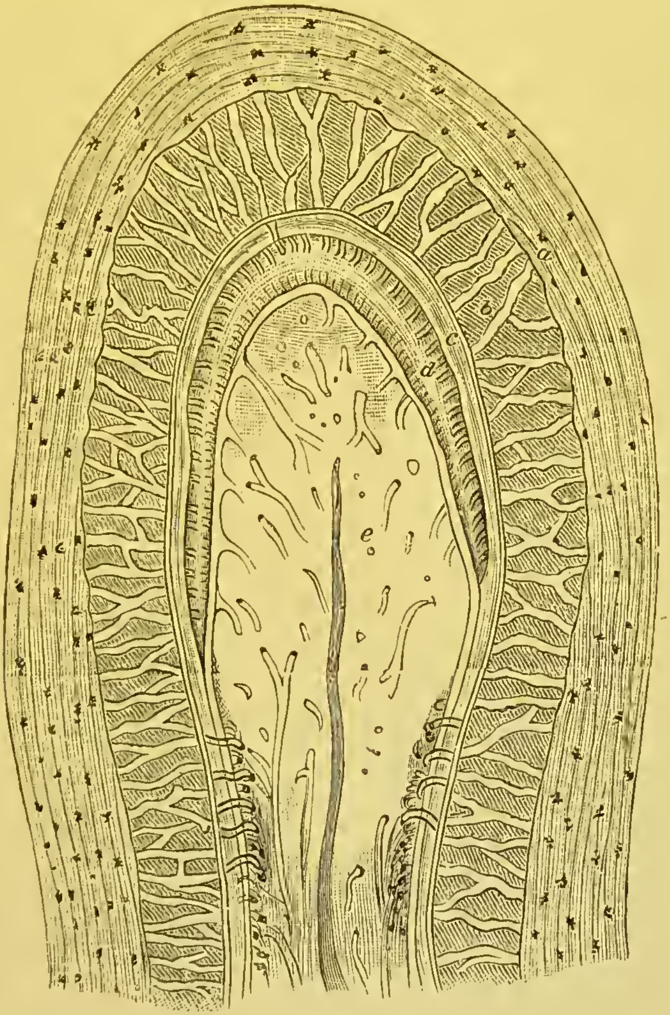

Fig. 149.—A Magnified Vertical Transverse Section through the Summit of the Shaft of the Tooth of the Adult *Mesoplodon layardi*.

The tooth is made up of the following tissues, from above downwards: *a*, cement; *b*, vaso-dentine; *c*, a layer of more opaque modified vaso-dentine; *d*, dentine; *e*, modified vaso-dentine of the centre of shaft. (After Turner.)

My reasons for regarding this singular tooth as a pathological peculiarity are these :—

(1) The elongated portion of the tooth really consists of the fang, and in many animals, even where the teeth do not grow from persistent pulps, there is a great tendency, when the crowns are unopposed, for the fangs to elongate. This condition is often very conspicuous in old horses.

(2) The nutritive conditions of the tooth are exceedingly advantageous for overgrowth. Not only is it well supplied from the pulp, but its layers of vaso-dentine place it in suitable relation with the alveolo-dentar periosteum.

(3) Judging from the condition of the crown of the tooth even in adult whales, it can be subjected to very little friction. Hence the structure, mode of nutrition, and lack of opposition, place this tooth in a highly favourable condition to elongate.

Before dismissing the subject, it will be well to point out how simple a matter it is to show that overgrowth and hypertrophy of an organ, especially if excessive, must almost of necessity lead to dwarfing of the structures more or less associated with it. This is particularly well illustrated in the case of teeth. In man any tooth differs in size but little from those immediately adjacent; but if, as in the case of rodents, the incisors increase in size out of all proportion to the neighbouring teeth, their augmentation in volume will lead to a "diversion of the nutrient stream" in their favour, but certainly to the detriment of the teeth immediately succeeding them in the dental series; and, as a matter of fact, these victimized teeth become so deprived of the essential element—blood—that they remain of stunted size, or, in some cases, entirely disappear. It must also be borne in mind that as the incisors increased in size, the effective employment of the succeeding teeth (canines and premolars in rodents) became reduced to a minimum, so that diminished usage would also tend to lower the vascular supply: thus the two factors, diminished function and diversion of nutrient fluid, have brought about extreme atrophy and, in many cases, total disappearance of teeth.

Numberless other instances might be quoted; indeed they must readily suggest themselves to any meditative mind. The cases of *Mesoplodon* and *Monodon* seem to me to be extreme examples of this remarkable process.

Hernia.—Many persons think that hernial protrusions of the abdominal viscera are peculiar to human beings. This is clearly erroneous, and cannot be entirely due, as many suppose, to their upright posture. As a matter of fact, inguinal herniæ—that is, visceral protrusions following the course of the inguinal canal—occur in monkeys, sheep, horses, goats, and dogs. It is somewhat strange that hernia should not occur more frequently in many mammals, especially when we take into account the patent condition of the funicular pouch of peritoneum in so many of them, whereas in man it is normally obliterated. The frequency of hernia in man seems rather to point to the fact that the various strains and pressure incidental to civilization play a large part in its causation.

A typical example of an inguinal hernia which occurred in a round-face monkey, *Macacus cyclopis*, came under observation. In this case the funicular pouch is persistent on both sides. The left inguinal canal is occupied by a large piece of the great omentum. A second example was dissected also in a monkey, *Macacus sinicus*. A mass of omentum occupied the inguinal canal of the right side. The left spermatic cord was occupied by a varicocele.

The most curious example of hernia I know of occurred in a frog, *R. temporaria*. In this case the small intestines, stomach, and part of the lung have escaped through a rent in the abdominal muscles, and occupied the lymph-sinus.

The Descent of the Testes and Ovaries.—The descent of the testes is a subject which has exercised the ingenuity of several excellent anatomists; notwithstanding the attention it has received, a satisfactory explanation of the phenomenon is not forthcoming. Although the thickened bands forming the gubernaculum have been put forward as the main agents in producing the remarkable change of position in the testes, similar structures are not found in connection with the ovaries when they undergo a like translocation; and in some instances actually simulate the testes, in that they pass between the tissues of the abdominal walls, and occupy a position in the labium major.

In the evidence subsequently to be analysed, I shall endeavour to show that the descent of the testes is in every respect to be regarded as a hernia of that body, and in the first instance probably originated as such. In this way it comes into the category of inherited pathological conditions.

It behoves us in the first place to briefly review the main peculiarities in the positions assumed by these bodies in animals generally.

In all vertebrata, up to and including Monotremata, the testes lie in the abdominal cavity, occupying some position in relation to the kidney—in front of it, as in birds and snakes; posterior to this organ, or lying on its ventral aspect, as in many batrachians and in the porpoise.

In man, the testes originally occupy similar positions; but as the embryo progresses towards maturity they begin to descend towards the inguinal canal, a position characteristic of the hedgehog. By degrees they pass through the abdominal wall, accompanied, and in most instances preceded, by a diverticulum of the peritoneum, to occupy a post-penial position, lodged in a cutaneous pouch—the scrotum. For some time the pouch of peritoneum retains its communication with the general cavity of the body; in very many mammals, horse, monkeys, etc., it remains open throughout the whole of life. In man, that portion of the funicular pouch which is in relation with the testicle is termed tunica vaginalis; but the portion extending from the epididymis normally becomes obliterated as far as the inguinal ring; exceptionally, however, it presents the patent condition characteristic of so many mammals.

Among topographical anomalies assumed by the testes in man, the following are the most important:—It may be retained in relation with the kidney—monotrematous form—or may be detained at the ring, as in the hedgehog.

Exceptionally it lodges in the canal, as is seen in the hare; or it on very rare occasions occupies the perinæum, as is normal in the Suidæ. Among rarer positions may be mentioned Scarpa's space. The peculiar *pre-penial* position seen in the marsupialia, and characteristic of them, I have not met with in man.

Returning to the question of hernia, an abdominal hernia may be defined as the protrusion of the viscera through the parietes. Such an event is of very common occurrence in the human subject, partly on account of the upright position of the body, and the various mechanical strains civilization imposes upon it. The contents of a hernial sac are, as a rule, the most movable bodies of the abdomen, such as omentum and intestines.

The following are the chief reasons which induce me to regard the descent of the testicles as of the nature of a perpetuated hernia :—

(1) They leave the abdomen at a region where hernia would be most likely to occur, viz., at points of least resistance.

(2) The more erect the posture assumed by the animal, the greater is the liability to hernia. Hence, mammals, like the kangaroo, monkeys, etc., present descended testicles, whilst in mammals which habitually maintain the horizontal position, like the Monotremata, porpoise, etc., the testicles are renal in position.

(3) Hanging by the mesorchium, pendulous in the body-cavity, the testicles are in the most favourable position possible to become herniated in all conditions involving increased strain on the abdominal parietes.

(4) Descended testes are certainly not an advantage to the animal; perhaps the reverse of this is true.

I have heard it argued by surgeons that the descent of the testes is of obvious advantage to man, in that it allows diseases of those organs to be efficiently dealt with. This is, however, weak argument, for the same line of reasoning would apply to the kidneys, the lungs, and other viscera. The descent of the testes has many disadvantages.

(1) They are more exposed to injury. (2) Their passage weakens the abdominal walls, and predisposes to hernia. (3) Hydrocele, hæmatocele, and other scrotal affections would be unknown. Retained testes are liable to injury from pressure when lying in the canal, and from irritation due to dragging of the cord, etc., and, like other malformed organs, are predisposed to cancer. Carefully considering the evidence, those animals with the testicles lying normally under the kidney are in a more satisfactory condition than those having these organs normally lodged in the scrotum.

CONCLUSION.

The main object of these "Lectures" is an endeavour to show that the same laws which regulate physiology rule pathology. The latter is, for all intents and purposes, to be regarded as the science that deals chiefly with physiological processes in excess or in abeyance. Admit this, then the laws of evolution apply to pathology as well as to the ordinary events of animal life. Throughout this chapter every opportunity has been taken to bring under the reader's notice instances of the hereditary transmission of defects. A few additional examples will be cited in conclusion.

The following observations, collected for me by my talented young friend, Mr. T. D. A. Cockerell, show clearly that in snails, abnormalities may be transmitted and perpetuated. Normally, the shell of a mollusc has a dextral spire. Among all the genera of mollusca, there are a very few in which the spire is sinistral, *e.g.*, *Clausilia*. In all the species of the genus *Helix* there are a *very* few in which the spire is sinistral, *e.g.*, *H. hortensis*, monst. *sinistrosum*. The normal *sinistral* genus *Clausilia* presents a few species which are always dextral, *e.g.*, *C. lividia*; whilst the normally sinistral species of *Clausilia* sometimes present dextral specimens, *e.g.*, *C. nigrosa*, monst. *dextrosum*.

In the Polynesian genus of land shells, *Partula*, the following facts have been observed*:—In *P. spadicea* the spire is constantly sinistral, whilst *P. Otaheitana* has the majority of specimens sinistral. In *P. vexillum* there is one sinistral to fifty dextral, whilst in *P. affinis* the proportion sinks to one sinistral to several hundred dextral.

In one case, that of *H. aspersa*, a sinistral monstrosity was induced to breed in captivity, but the progeny were all dextral; nevertheless, Mr. Cockerell believes that sinistral monstrosities do produce sinistral offspring.

A marine shell, *Fusus antiquus*, is normally dextral, a sinistral shell being very rare. This species is common in the Eocene formations, and here it is normally sinistral, a dextral one being uncommon. From being anciently sinistral it has come to be normally dextral.

Some shells have the whorls separated, constituting an abnormality known as scalariform monstrosities. In the Isle of Syra the scalariform specimens of *Helix rupestris* far exceed the type-form in number ("Zoo. Rec.," 1880).

Professor Turner† has recorded an interesting instance of the hereditary transmission of a deformity of the hand which he observed in one of his pupils.

The deformity consisted in a shortening of the left ring finger, which was 1·2 inch shorter than the middle finger, and only 0·5 inch longer than the little finger of the same hand. The shortening was due to imperfect growth in length of the metacarpal bone, which was about three-quarters of an inch shorter than it ought to have been. The phalanges were normal in size.

Inquiry showed that the deformity had been noticed in members of the family for at least five, and perhaps six, generations. A peculiarity in the case was that the deformity had alternated from mother to son, and then again to the female line, as shown in the accompanying tree, drawn up by Professor Turner. The persons who exhibited the deformity are indicated by *.

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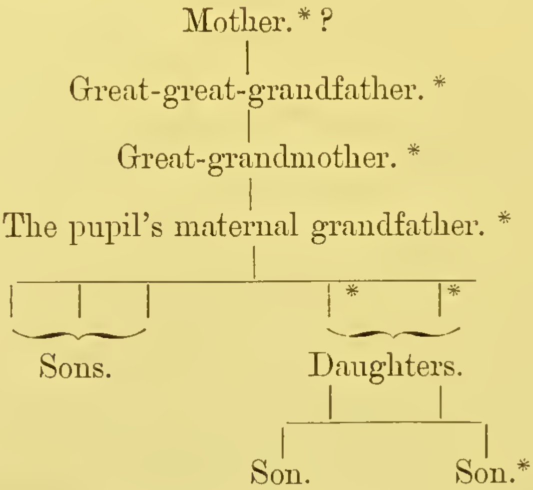
* "Zoo. Rec.," 1881.

† "Journ. of Anat. and Phys.," vol. xviii., p. 463.


Mother.* ?
Great-great-grandfather. *
Great-grandmother. *
The pupil's maternal grandfather. *
*
*
Sons.
Daughters.
Son.
Son.*

It is an excellent and striking instance of hereditary transmission.

It is well known that fish, like other animals bred in captivity, are apt to vary. This is especially true of the carp family. Lord Arthur Russell† has stated that one of the most remarkable examples of the constant species of carp in Germany is the one known as *Spiegelkarpfen*. In this variety, which is exceedingly fine, the scales only persist along the line of the back and on the sides of the fish in two or three irregular rows. These few remaining scales attain a great development; the rest of the body is naked. Specimens in which the scales only remain along the dorsal line go by the name of saddle-carp among German fishermen. Occasionally the scales are wanting altogether, and the carp is covered with a leathery skin, and is popularly called *Lederkarpfen* or leather-carp. This variety has been described as a distinct species (*C. nudus* and *C. coriaceus*), and is named by Agassiz *Cyp. alepidotus*. Haeckel ("Austrian Ichthyology," p. 58) and other authors believe the total loss of scales to be an effect of age on single specimens of the spiegel-carp variety, in which the number

† "Proc. Zoo. Soc.," May, 1873.

of scales was already reduced to a minimum. Lord A. Russell showed *C. nudus* to be a constant variety, without scales from its birth. All these varieties are considered better for the table than the common carp, and command a higher price in the German fish-market.

If such defects as these can be inherited—and their transmissibility is unquestionable—there can be no reasonable ground for refusing to admit that various remarkable structures which characterize certain species of animals may have originated as defects.

When discussing the case of the babirussa, mention should have been made of the following paragraph in Darwin's "Descent of Man":—

"Although the males of so many members of the pig family are provided with weapons, they seem to have been acquired within a rather late geological period. Dr. Forsyth Major specifies several Miocene species, in none of which do the tusks appear to have been largely developed in the males; and Prof. Rütimeyer was formerly struck with the same fact."

Among other instances of peculiar anatomical arrangements which probably had a pathological origin, may be mentioned the atrophy of the right ovary and oviduct in birds, as well as the curious disappearance of the right carotid artery and jugular vein in many species of the feathered tribe. Doubtless many other examples will suggest themselves to the minds of those who meditate on the subject.

The main conclusion seems to be this: Evolution has played as important a part in pathology as in biology, and structural peculiarities, pathological in their origin, have been transmitted as race-characteristics in more than one group of animals. Every great class of animals is distinguished by anatomical details, habits of life, and surroundings from other groups. These differences involve liabilities to some diseases, and comparative immunity from others. So far as our present knowledge extends, we know that certain diseases occur with extreme frequency in one class of animals, and are rarely seen in another.

These circumstances clearly indicate that in discussing the doctrine of evolution we have not merely to take normal structure and function into account, but aberrations of structure and function as well. As man in his bodily structure is kindred with the brutes, so he shares with them, and they with him, the liability to disease, inherited and acquired.

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